MARYLAND BIOLOGICAL STREAM SURVEY
2001
QUALITY ASSURANCE REPORT

CHESAPEAKE BAY AND
WATERSHED PROGRAMS
MONITORING AND
NON-TIDAL ASSESSMENT

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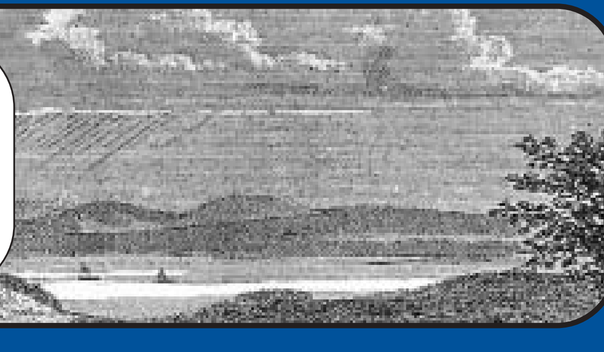

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Maryland Biological Stream Survey

2001

Quality Assurance Report

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FOREWORD

This report, *Maryland Biological Stream Survey 2001 Quality Assurance Report*, was prepared by Versar, Inc. and supports the Maryland Department of Natural Resources' Maryland Biological Stream Survey (MBSS) under the direction of the MBSS QC Officer, Mr. Paul Kazyak of the Monitoring and Non-tidal Assessment Division. Versar's work and this report were prepared under Maryland's Power Plant Research Program (Contract No. K00B0200109 to Versar, Inc.). A major goal of the MBSS is to assess the ecological condition of Maryland's streams, with a particular focus on biological resources, but also evaluating water chemistry and physical habitat. This annual report presents results of the Quality Assurance/Quality Control (QA/QC) activities of the 2001 MBSS.

ACKNOWLEDGMENTS

The MBSS 2001 QA Report has been a cooperative effort among several agencies and consultants. We at Versar wish to thank Ron Klauda and Paul Kazyak from the Maryland Department of Natural Resources (DNR) for directing the program and supporting Versar in preparing this report as well as for comments received on a previous draft. We would also like to thank the University of Maryland's Appalachian Laboratory (AL) which provided the quality assurance data for water quality, Dr. Rich Raesly of Frostburg State University who provided taxonomic verifications of voucher fish specimens, and the MBSS field crews (both Maryland DNR and AL) for providing us with sampling records and answering questions. Versar managed data, conducted statistical analyses, and prepared this report. The success of the project resulted from the strong efforts of all these groups. We particularly thank the key individuals listed below for their contributions:

Versar	**AL**	**DNR**
Gail Lucas	Matt Kline	Ron Klauda
Sherian George	Katie Kline	Paul Kazyak
	Ray Morgan	Dan Boward
		Scott Stranko
		Marty Hurd
		Tony Prochaska
		Chris Millard
		Ann Lenert

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1 INTRODUCTION

1.1 BACKGROUND

The purpose of this report is to document the Quality Assurance/Quality Control (QA/QC) activities associated with the 2001 Maryland Biological Stream Survey (MBSS), a monitoring program conducted by the Maryland Department of Natural Resources (DNR). QA/QC activities have been an integral part of the MBSS since its inception in 1993, but until the 2000 sampling year, annual summaries of QA/QC activities were not compiled. MBSS data is now being used for a wide array of resource management and regulatory decisionmaking; this report provides users with a convenient means to evaluate MBSS data quality and provide feedback to improve the program.

The year 2001 was the second year of five years of sampling planned for Round Two of the MBSS program. The primary objectives of the MBSS are to:

- assess the current status of biological resources in Maryland's non-tidal streams;
- investigate trends in these biological resources;
- quantify the extent to which acidic deposition is affecting biological resources in the state;
- examine which other water chemistry, physical habitat, and land use factors are important in explaining the current status of biological resources in streams;
- provide a statewide inventory of stream biota; and
- target future local-scale assessments and mitigation measures needed to restore degraded or threatened biological resources.

To achieve these objectives, the Maryland Department of Natural Resources (DNR) conducts field studies that involve the collection of biological, physical habitat, and water quality data, as well as information on anthropogenic stressors. Biological variables are used to determine the ecological condition of streams within a watershed. Habitat variables are used to describe the condition of the aquatic and riparian environment. Water quality and anthropogenic stressor data are used to describe and identify potential sources of impairment affecting the stream.

The Quality Assurance (QA) program for the MBSS was designed (1) to ensure that data are of known and sufficient quality to meet the primary objectives of the MBSS and (2) to provide estimates of the sources of variance associated with the individual variables being measured. The major components of the QA program include the following:

- assignment of responsibility and accountability to key personnel;
- development of Data Quality Objectives (DQOs);
- codification of project protocols and guidelines;
- thorough investigator training;
- comprehensive documentation of procedures and results;
- integrated field and laboratory data management;
- auditing and evaluation of data acquisition;
- assessment of QA results for data interpretation and program refinement; and
- QA and peer review of reports.

In addition to documenting the QA activities of the 2001 MBSS sampling, this report evaluates the QA results which include comparisons of replicate sample and independent field audit data. The report also documents and evaluates QA steps taken throughout the site selection, data collection, data management, and reporting phases. The recommendations of this QA report will be used to identify ways to improve and maintain the quality of the MBSS.

MBSS 2001 results are presented in the 2001 data report (Roth et al. 2002).

1.2 ROADMAP TO THIS REPORT

This report presents the activities and results of the 2001 QA program and includes 12 chapters and 4 appendices. Chapter 2 identifies the key personnel and their responsibilities during the MBSS 2001. Chapter 3 discusses data quality objectives. Chapter 4 presents the survey design, sample selection, landowner permissions, site selection, and GIS meta data. Chapter 5 references the standard operating procedures for sampling and other program activities. Chapter 6 summarizes the training requirements for all field personnel. Chapter 7 presents the documentation procedures of the program. Chapter 8 discusses data acquisition audits. Chapter 9 summarizes the results of the data quality assessment with sections on water quality sampling, benthic sampling, fish sampling, herpetofauna sampling, aquatic vegetation sampling, and habitat sampling. Chapter 10 includes information on reporting and Chapter 11 concludes the report by providing recommendations. Chapter 12 contains References. Appendices include (A) notes recorded by the MBSS QC Officer, (B) the Appalachian Laboratory's *Summary of Quality Assurance/Quality Control Results from Spring 2001 Water Chemistry Analysis for the Maryland Biological Stream Survey*, (C) benthic taxa lists for sites with duplicate field samples, (D) benthic taxa lists for sites with duplicate laboratory samples, and (E) the number of individual fish species samples compared to the number retained as fish voucher specimens.

2 KEY PERSONNEL

To ensure that adequate responsibility and accountability for MBSS data are maintained, an organizational structure defining the responsibilities for MBSS key personnel was prepared. Because several organizations are involved in implementing the MBSS, adherence to the chain of authority and responsibility is especially important to the MBSS QA program. A number of personnel report directly to the Project Officer, including the Training Officer, the Quality Control Officer (QC Officer), the Field Crew Supervisor for each organization involved in field sampling, and the Data Management and Analysis Officer (DM Officer). The responsibilities of each of these personnel are described below:

- <u>Project Officer (Paul Kazyak)</u> - The MBSS Project Officer has overall responsibility for successful completion of the MBSS. Specific duties of the Project Officer include selection of project staff, direction and approval of training activities, contractor oversight, liaison with the public and resource agencies, document review, and peer review solicitation.

- <u>Training Officer (Paul Kazyak)</u> - The Training Officer is responsible for training all field sampling personnel. At the direction of the Project Officer, the Training Officer coordinates with the QC Officer and the Field Crew Supervisor to implement remedial or additional training deemed necessary between MBSS field sampling periods.

- <u>Quality Control Officer (Paul Kazyak)</u> - The QC Officer is responsible for implementation of all aspects of the MBSS QA program, including inspection of field crews, data validation, taxonomic verification, site confirmation, calibration and maintenance of equipment, adherence to established protocols, and prompt identification of necessary remedial or corrective actions. The QC Officer is also responsible for oversight of laboratory QA managers to ensure that all MBSS laboratory activities meet MBSS QA/QC requirements.

- <u>Data Management and Analysis Officer (Martin Hurd)</u> - The DM Officer is responsible for receiving, reviewing, and signing off on the original data sheets, as well as supervising and verifying data entry.

- <u>Field Crew Supervisor (Scott Stranko)</u> - The Field Crew Supervisor is responsible for day-to-day communication with Crew Leaders, coordination and approval of sampling schedules and itineraries, and other activities designated by the Project Officer.

- <u>Crew Leader (Scott Stranko, Anthony Prochaska, Matthew Kline)</u> - The Crew Leaders are responsible for crew safety, sample scheduling, equipment maintenance and calibration, and performance of all sample collection activities in accordance with procedures and QA/QC requirements specified in the MBSS sampling manual.

- <u>Field Sampling Crew</u> - Members of the sampling crew are responsible for carrying out the instructions of the Crew Leader and informing the Crew Leader of any unsafe conditions, equipment failures, or other problems observed that could jeopardize the health and safety of the crew or the quality of sample collections. Crew members for 2001 included: Marty Hurd, Jay Killian, Karl Routzahn, Chris Millard, Brenda Morgan, Miguel Dodge, Derek Wiley, Jamie Welch, Josh Fair, Greg Turner, Natasha Davis, Julie Brown, David Kazyak, and Kenny Mack.

3 DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) are statements that specify the desired quality of data; they provide a rigorous means of determining whether the data have the certainty needed to support specific decisions. In general, data quality may be described by the precision, accuracy, representativeness, completeness, comparability, and sensitivity of data (U.S. EPA 1995).

Data from the MBSS are being used to support management decisions such as the following:

- a determination of the extent and magnitude of acidic deposition effects on stream biota in Maryland;
- an evaluation of the degree to which the flowing, non-tidal waters of Maryland have balanced, indigenous populations of biota as specified in the Clean Water Act;
- a determination as to whether specific waters of the state require further investigation of stressor sources and impacts;
- prioritization of watersheds for protection, restoration and/or enhancement;
- a determination as to which anthropogenic stressors need to receive more intensive management and enforcement activities;
- further development of validated biological indices for evaluation and monitoring of impacts from anthropogenic stresses; and
- listing and protection of rare aquatic species.

Decisions are often based on quantitative statements about the condition of non-tidal streams on several different spatial scales. These include (1) the statewide network of all non-tidal, 4th order and smaller stream reaches of the State of Maryland, (2) the Maryland 8-digit watershed used in the state's Water Quality Inventory (305(b) report), and (3) the smaller 12-digit subwatersheds contained within the 8-digit watersheds, which are also evaluated to determine impairment. For example, MBSS data were used in the most recent statewide water quality inventory (Clean Water Act 305(b) list) and to identify impaired waters at both the 8-digit and 12-digit watershed levels.

DQOs specify how precise and accurate MBSS data must be to support effective decision making. It is important to note that DQOs for the MBSS are target values for data quality and are not necessarily criteria for the acceptance or rejection of data. One goal of the MBSS QA program is to develop quality objectives for each major quantitative variable in the survey. The State need such measures to assess the level of uncertainty involved in their decisions about stream quality, including the listing of impaired waters.

The original impetus behind the MBSS was to examine the effects of acidic deposition on stream biota. Since that time, additional uses of MBSS data have been identified. Because the uses of MBSS data evolves over time, the DQOs will periodically be updated, taking into account more QA/QC data as they becomes available.

3.1 SOURCES OF SURVEY ERRORS

As discussed throughout this report, the organization and development of the MBSS have led to the incorporation of procedures to measure and reduce Survey errors. The objective is to attain high precision for all survey estimates, and minimize or eliminate sources of bias. When setting DQOs, one can differentiate between sampling errors and nonsampling errors in the survey (Lessler and Kalsbeek 1992).

3.1.1 Sampling Errors

Sampling errors are differences between the parameter estimated from the sample and the actual parameter value. This type of errors result from collecting measurements from only part (i.e., the sample) of the population of streams. When making inferences about a parameter (e.g., mean IBI) for a population of streams (e.g., an 8-digit watershed) the associated sampling errors depend on the spatial variability (and temporal variability when combining samples across years) in the variable measured, as well as on the sample sizes and the survey design. Because the MBSS is probability-based, the precision of an estimated parameter can be measured by the standard error or by the relative standard error (Cochran 1977). The MBSS designs support the use of consistent estimators of average stream condition within and across watersheds because the inclusion probabilities of all sites are known (e.g., Stevens, 1994). Thus, estimates that are close to the true average for the population of streams being surveyed can be achieved for moderate to large sample sizes. The precision of estimated mean IBIs and other parameters are quantified for 8-digit watersheds and for the population of streams.

3.1.2 Nonsampling Errors

Nonsampling errors in the MBSS primarily originate from three general sources:

- Problems with the sampling frame (frame error);
- Failure to obtain data from selected representative study sites (non-response errors);
- Inadequacies in the process of obtaining survey measures from the sites actually sampled (measurement errors).

These sources of survey errors are evaluated qualitatively throughout this report. In addition, the report quantitatively evaluates measurement errors for selected MBSS parameters.

3.1.2.1 Sampling Frame

The current MBSS population of interest includes all non-tidal, 4th-order and smaller stream reaches of the State of Maryland. The sampling frame used to obtain representative samples of stream segments from this population is based on a reach file digitized from 1:100,000-scale USGS topographic maps. Exceptions within this population are non-wadeable impoundments and impoundments that substantially alter the riverine nature of the reach. Problems with the sampling frame generally relate to factors that would be prohibitively expensive to control for. No map is perfect, and the mapping of non-tidal streams represent a snap-shot in time. In dry years, some of the smaller reaches may not exist. Also, in a few cases inaccuracies in the reach file may result in a sample selection that includes sites that are outside the actual stream network (i.e., streams with tidal influence). In general, however, the current reach file provides a good sampling frame. In the future, the frame may be based on the National Hydrography Data set (NHD). While initially based on 1:100,000-scale data, the NHD is designed to incorporate and encourage the development of higher resolution data, for example at the 1:24,000 scale required by many counties.

3.1.2.2 Non-Response Errors

Non response errors in the MBSS occur when the landowners do not allow sampling on their property, when landowners cannot be contacted, or when some selected stream segments cannot be accessed for other reasons, such as summer drought.

3.1.2.2 Measurement Errors

The extent of error associated with a particular measurement method can be distinguished as between precision and accuracy (Lessler and Kalsbeek 1992). Precision is the degree to which repeated measurements of the same variable yields consistent values and is calculated in this report using the Relative Percent Difference (RPD) when there are only 2 duplicate samples or Relative Standard Deviation (RSD) when there are 3 or more replicate samples. Accuracy refers to the net difference between the obtained measurement and the true value (i.e., the bias).

4 SURVEY DESIGN AND SITE LOCATIONS

Obtaining high quality data depends as much on selecting the proper sites to sample as it does on effectively sampling them. The MBSS includes in its QA/QC activities considerations related to the sample frame of Maryland streams, survey design, sample selection, and obtaining landowner permissions. Each of these entails certain assumptions about how well the sampled sites represent the true population of interest–Maryland's 4th-order and smaller, non-tidal streams.

4.1 REACH FILE DESIGNATION

To improve the resolution of MBSS base maps for Round Two sampling (which began in 2000), the decision was made to use a 1:100,000-scale map rather than the 1:250,000-scale map used in Round One (1995-1997) (Southerland et al. 2000). The base data source was USGS Digital Line Graphs (DLGs; http://www.edc.usgs.gov/glis/hyper/guide/ 100Kdlgfig/states/MD.html) derived from 30- by 60-minute quadrangle maps. This 1:100,000-scale reach file is consistent with the National Hydrography Dataset (NHD), an EPA product designed to incorporate both the EPA Reach Files (RF3) and the USGS DLGs. The EPA RF3 file was also developed from these USGS maps, but contains reported errors, including missing stream reaches. It was anticipated that the use of the original USGS maps in developing the MBSS sample frame would circumvent many of the errors associated with the RF3. Another advantage of using this smaller scale reach file was that it would allow for better characterization of headwater stream features, which is important in determining the status of acidified streams and fish and benthic macroinvertebrate communities in headwaters.

In the USGS stream reach files, reaches are not assigned a Strahler stream order, a key parameter needed for the MBSS site selection process. Therefore, this variable had to be attributed manually. Examination of hard-copy topographic maps from Maryland and adjacent states aided in determining the direction of stream flow when it could not be determined from the USGS maps alone. Attributes from the USGS files such as lakes, large rivers, ditches, and canals were also used when the designation of stream order was not straightforward. For example, in order to properly designate flow within a watershed, stream connections were made between streams that were connected by what USGS designated as a canal. All stream order designations were reviewed by a second GIS analyst for continuity within and between watersheds, but is possible that some errors were introduced during this process. We believe that this method of attributing stream order to the sample frame was likely as accurate as an automated process (which was unavailable), though not as cost effective. For more detailed documentation concerning MBSS reach file development see Brindley (2001). In braided third-order streams such as those in the Zekiah Swamp watershed, each braid was designated on the map as a separate third-order stream and counted toward the total number of third-order stream miles, even though in practice all braids of a stream are sampled when an MBSS site falls on any single mapped braid. In the field, it is apparent that individual braids are clearly linked, and in fact, during spring, high flow are often connected so that individual channels cannot be distinguished. Although it is difficult to anticipate and correct this and other map deficiencies before sampling, analyses of results in Zekiah Swamp and other watersheds with braided streams should consider the impact on estimates and weightings.

Another potential error in the sample frame is the assignment of an MBSS site below the head-of-tide. During sample frame development, a tidal boundary was developed using existing knowledge of the head-of-tide. In 2001, no segments were sampled below the head-of-tide. An additional problem that may exist in the 1:100,000-scale reach file is the possibility that non-tidal waters extend further downstream than delineated on the reach file, resulting in an underestimate of non-tidal species richness in some basins. However, given the small number of segments selected for sampling during 1995-1997 that fell into this zone - on the order of two sites (assuming a similar level of error for overestimating the tidal boundary as for underestimating it) - it is unlikely that population estimates for basins would change substantially if the head-of-tide was perfectly defined and no error was associated with physically locating the segments identified for sampling.

Due to inherent discrepancies between any map and the real world, errors similar to those encountered using the Round One 1995-1997 sample frame (1:250,000) may also occur in Round Two (1:100,000). Although the Round Two digitized stream reach file accurately represented Year 2001 streams at the vast majority of sites, a small number (approximately 8%) of MBSS 2001 sites were moved from the original GIS-generated coordinate location once field crews assessed the actual condition of the site. New coordinates were noted from field global positioning system (GPS) readings, recorded on the data sheets, and transferred to the MBSS database. In some cases, these discrepancies may have resulted from changes in the stream channel, since the development of the USGS reach file, either from anthropogenic or natural causes.

More generally, it should be emphasized that the 1:100,000-scale reach file is only one representation of "real world" streams. Many Maryland counties use the even finer scale 1:24,000 topographic map, which would include considerably more smaller streams than the 1:100,000-scale maps used by the MBSS. For example, in Seneca Creek, located in Montgomery County, streams on the 1:100,000-scale map and the 1:24,000-scale map overlap for approximately 60% of the stream length. Thirty-eight percent of streams are located only on the 1:24,000-scale map, while the remaining 2% are found only on the 1:100,000-scale map. These differences are attributed primarily to the inclusion of smaller streams on the 1:24,000 map, but also to the greater sinuosity of streams depicted on the 1:24,000 map.

Although the use of the 1:100,000-scale map has increased the number of stream miles in the population of streams potentially sampled by the MBSS, there are still many smaller, headwater streams being excluded from sampling. The use of a 1:24,000-scale map may be considered for the third round of MBSS sampling.

4.2 SURVEY DESIGN

For the 2000-2004 MBSS, the decision was made to focus on stream condition at a smaller, watershed scale, rather than the larger drainage basins scale used in the first round of sampling (Southerland et al. 2000). The State of Maryland contains 138 8-digit watersheds, as defined by Maryland DNR and Department of the Environment (MDE). Four of these are not relevant to the MBSS, because they are located in the Chesapeake Bay or have no non-tidal stream miles. Locating the required number of sites (minimum of 10) in each of the remaining watersheds would be prohibitive given the time frame and resources available to the MBSS. Therefore, the smallest 8-digit watersheds were grouped together into "combined" Primary Sampling Units (PSUs) based on proximity and similar land uses. This process resulted in a total of 85 PSUs (one of which contains the 4 completely tidal watersheds), of which 55 are 8-digit watersheds and 30 are "combined" PSUs containing two or more 8-digit watersheds. For a PSU map and sampling schedule, see the MBSS 2000 Report (Roth et al. 2001a).

Approximately one-fifth of the PSUs are sampled in each year of Round Two, following a schedule that provides for sampling of all PSUs over the five-year period. Within each PSU selected for 2001 sampling, 10 sites were randomly selected in each PSU. Although this sample design allows for the collection of data in all sampleable 8-digit watersheds, the use of combined PSUs means that not every 8-digit watershed will contain the 10 sites needed for precise estimates. Therefore, conditions in these watersheds can only be described as part of the combined PSUs (which may include widely different conditions). While grouping these watersheds to facilitate sampling eliminates many of them from including consideration in the State's proposed biocriteria framework at the 8-digit level (which requires 10 sites), and individual site results can also be used in the biocriteria 12-digit subwatershed analysis.

4.3 SAMPLE SITE SELECTION

For the 2000-2004 MBSS, a FORTRAN program was used to pick random sites within each PSU. These sites were mapped and examined by eye by a GIS analyst to ensure that all sites fell on streams, that no sites fell on a confluence, and that no sites were within 75 meters of another site. Ten sites per PSU were allocated to the majority of PSUs, although the 21 PSUs with the most stream miles received additional sites in proportion to the number of stream miles they contained. Sites were also allocated based on the proportion of first- and second-order streams to the third- and fourth-order streams where possible. It was understood that Round Two's greater focus on small streams (Round One's sampling effort was allocated equally to first-, second-, and third-order streams statewide), would likely result in less precise estimates of many gamefish populations (which are concentrated in larger streams). In combined PSUs, sites were allocated by 8-digit watershed, where possible, to provide some sites in the smaller 8-digit watersheds. Where this stratification was employed, stream order was not considered in site selection.

4.4 LANDOWNER PERMISSIONS

Obtaining permission to assess private properties is critical to a random survey such as the MBSS. For the 2001 MBSS, more than 800 landowners were contacted to request permission to access field sites. As part of the process, landowners were identified using county tax maps and subsequently contacted by mail or by telephone. A handwritten record was maintained for each landowner contacted, listing the site number, landowner name and phone number or address, parcel number, and date/time of the contact. This information was entered as a relational database in Microsoft Access. A copy of this record was taken into the field at the time of field sampling and proved to be highly useful on the few occasions when field crews were approached by landowners who did not recall giving permission and co-owners (e.g., spouses) who were not aware that permission had been granted.

Problems in the landowner permission process usually involved inaccuracies either in the tax maps or in the telephone directories used to identify phone numbers of potential landowners, resulting in the contacting of the wrong person. Other problems included:

- The sale of the property since the generation of the tax maps, with no way to contact the new owners;
- Deceased owners listed in the tax maps with no further point of contact;
- Incorrect/old phone numbers; and
- Letters returned to sender.

4.4.1 Landowner Permission Rates

For the MBSS 2001 sampling, the overall permission success rate was 68%. Nine percent of responses received were permission denials, while 23% of attempted contacts did not respond. Of the landowners that did respond,88% granted permission while 12% did not. Table 4-1 gives a breakdown of permission rates by PSU.

It was noted that public reluctance to allow the field crews on private property appears to have increased since the 1995-1997 field seasons. Not only did the people contacting the landowners have more refusals and nonresponses (combined) than in the past, but the field crews reportedly had to deal with more uncooperative landowners while sampling. This may be a result of increased restrictions for farmers concerning nutrient loading to the Bay and of a general increasing distrust of the government. In 2001, the lowest permission rate (45%) was in the Assawoman/Isle of Wight/Sinepuxent/Newport/Chincoteague Bays PSU. If this trend continues throughout the second round of sampling, especially among the farmers on Eastern Shore, a bias could be introduced into the survey's estimates of stream condition.

4.5 SITE LOCATIONS

In several cases, the proximity of streams to each other (especially near confluences), coupled with the locational error of the GPS receiver resulted in difficulty determining which stream was selected for sampling. In all cases, careful examination of tax maps, the MBSS stream system map, and topographic maps enabled Crew Leaders to resolve the issue in the field. To date, no records have been kept to identify the sites where resolution was necessary, but the proportion of these sites was small (approximately two sites per year).

4.6 GIS META DATA

To report upstream catchment area and land use for the MBSS 2001 sites, catchment boundaries were digitized automatically by using site locations (as pour points) and 30-meter USGS Digital Elevation Model (DEM) data by calculating flow direction and flow accumulation. Because of low elevations, catchments were digitized manually on the eastern shore. Fifteen catchments were also digitized manually to check the automated process. Comparisons of catchment area determined by both methods were within 5% of each other. The catchments were digitized up to the applicable Maryland 12-digit watershed linework to reduce digitizing error and sliver polygons. The digitized catchments were then overlaid on Multi-Resolution Landscape Characteristics (MRLC) data Version 040998 (April 9, 1998) land classifications to develop land use statistics for each MBSS site. For more information concerning the MRLC, see the MRLC homepage at http://www.epa.gov/mrlc.

Table 4-1. Landowner permission success rates for Primary Sampling Units (PSUs) sampled in the 2001 MBSS				
PSU	**Number of Stream Segments Targeted as Potential Sample Sites**	**Success Rate**	**No Response**	**Denial Rate**
Youghiogheny River	32	60%	15%	25%
Potomac River Upper North Branch	20	90%	5%	5%
Potomac AL Co/Sideling Hill Creek	20	90%	5%	5%
Seneca Creek	30	63%	27%	10%
Piscataway Creek	20	75%	20%	5%
Potomac Upper Tidal/Oxon Creek	20	65%	30%	5%
Zekiah Swamp	26	69%	31%	0%
Gilbert Swamp	20	70%	20%	10%
Assawoman/Isle of Wight/Sinepuxent/Newport/Chincoteague Bays	20	45%	35%	20%
Western Branch	20	60%	40%	0%
Patuxent River Middle	26	58%	27%	15%
Bodkin Creek/Baltimore Harbor	20	90%	10%	0%
Little Gunpowder Falls	20	65%	30%	5%
Sasssafras River/Stillpond-Fairlee	20	75%	15%	10%
Northeast River/Furnace Bay	20	55%	35%	10%
Nanticoke River	20	70%	15%	15%
Dividing Creek/Nassawango Creek	20	60%	35%	5%
Upper Pocomoke River	26	69%	19%	12%
Deer Creek	28	75%	14%	11%
TOTAL	428	68%	23%	9%

5 SAMPLING METHODS

The heart of the MBSS QA program is the set of standard sampling methods developed by the Project Officer, Paul Kazyak. These standard operating procedures contribute to the collection of high quality data by being comprehensive for, representative of, and sensitive to changes in the stream conditions being sampled. The comparability, precision, and accuracy of the data are best served by codifying these procedures in the *Maryland Biological Stream Survey Sampling Manual* (which is updated regularly; see Kazyak 2000, 2001). This manual provides health and safety guidelines, outlines QA/QC requirements, documents equipment needs and trip preparation requirements, in addition to presenting sampling and data management procedures for site selection, determination of sampleability, temperature logger deployment and retrieval, and water quality, benthic macroinvertebrates, fish, herpetofauna, and physical habitat data acquisition.

6 TRAINING REQUIREMENTS

An important aspect of the MBSS QA program is the mandatory training of field personnel that is conducted prior to sampling. The goal of the training is to ensure consistent implementation of required procedures and attainment of a minimum level of technical competency by each MBSS participant. This standardized training helps to maximize the comparability of data among field crews. In addition to crew training, Crew Leaders are given additional instruction and guidance to maximize consistency in decision-making. To meet the program's QA objectives for training, crew leaders must successfully pass examinations administered during annual training.

For personnel involved in sampling during the spring index period, training includes water quality and benthic macroinvertebrate sampling using MBSS procedures (Kazyak 2001). For personnel involved in sampling during the summer index period, training includes fish and herpetofauna sampling, habitat assessment, and a laboratory examination concerning the identification of Maryland fishes and herpetofauna. These taxonomy tests involve the identification of preserved fish and may underestimate the ability of the individual to identify live specimens.

During the summer training for the MBSS 2001 sampling, two of the three Field Crew Leaders received high scores on both the fish and herpetofauna identification tests. One Crew Leader did not attend the training due to injury, but a verification of his taxonomic knowledge was confirmed in the field by the QC Officer and another member of his crew passed this fish exam. Table 6-1 lists the three field crews and the number of people passing the taxonomy tests for each crew. When actually tested in the field, misidentifications were rare (in most cases, the specimen was labeled as unknown and sent to an expert taxonomist for verification).

Table 6-1. MBSS 2001 field crews and numbers passing fish and herpetofauna taxonomy tests with a minimum score of 90% correct

	Number Passing	
Field Crew	**Fish**	**Herpetofauna**
Appalachian Lab	1 (20%)	0 (0%)
DNR Crew 1	1* (20%)	2* (40%)
DNR Crew 2	2* (20%)	1* (20%)

* Number includes crew leader.
Note that the Appalachian Lab Crew leader did not attend training due to injury.

Members of several groups outside of the DNR MBSS field crews also took both the fish and benthic taxonomy exams. Because the MBSS is interested in integrating the data collected from these outside groups (several county and other citizens groups) into the Survey. The Survey is promoting and sponsoring training to improve consistency among the State and these other groups. In the future, the quality of these data should also be assessed. The MBSS is currently evaluating the standards that should be used for inclusion of such data.

7 DOCUMENTATION

To ensure scientific credibility, study repeatability, and cost effectiveness, the MBSS attempts to document all project activities. These activities include the following:

- landowner contacts;
- adherence to sampling protocols;
- equipment calibration;
- field sampling;
- chain-of-custody sheets;
- review of data sheets;
- extensive notes on field audits;
- information management;
- data quality assessment;
- data analyses; and
- interpretation of data.

To minimize the possibility that needed documentation or data are not recorded, standardized forms and on-site verification of form completeness by supervisory personnel are employed as part of the MBSS. These documentation procedures and requirements are more fully described in the MBSS Sampling Manual (Kazyak 2001 for year 2001 sampling).

7.1 FIELD INFORMATION MANAGEMENT

To facilitate data recording during inclement weather, MBSS data sheets are printed on waterproof paper. Backup copies of all field data sheets are made prior to submittal to the Data Management (DM) Officer.

To ensure that all field data for the MBSS are collected and recorded in a usable manner, data are recorded in the units specified on the MBSS data sheets. Recorded data are reviewed at the sampling site and the Crew Leader reviews and initials all data sheets prior to departure from the site. Legible copies of data sheets are provided to the DM Officer on an approximately bi-weekly basis during sampling.

During the 2001 sampling period, the above data recording procedures were followed and no data sheets were lost. However, there were some cases when the DM Officer did not receive copies of the data sheets within two weeks.

7.2 DATA ENTRY

Once the Crew Leaders have submitted legible copies of data sheets to the DM Officer, the QC Officer examines the sheets and records potential errors, documents and corrects discrepancies, and periodically alerts Crew Leaders to prevent similar errors in the future (see QC Notes in Appendix A). In the 2001 MBSS, errors that were noted and corrected included (but were not limited to) the following:

- Spelling errors for fish and herpetofauna species;
- Incorrect or misspelled stream names;
- Smears on data sheets and illegible handwriting;
- Inconsistencies in the listing of riparian buffer vegetation types;
- Meter calibrations not signed for;
- Blank spaces on data sheets;
- Page number not labeled on all pages;
- Inconsistent labeling of photodocumentation; and
- Field crew leader failed to sign for verification of benthic bottle labels.

To verify that all data collected at a sampling segment were complete and acceptable, data entry of all data sheets occurred after data sheets were received and reviewed by the DM Officer. Data entry was accomplished using entry screens designed in Microsoft Access to emulate the data sheet format (Figure 7-1). Whenever possible, QA/QC checks were embedded into data entry screens to ensure validity of data. With the exception of water chemistry and benthic lab identifications, all MBSS data were independently entered into two databases and compared using a computer program as a quality-control procedure. Differences between the two databases were resolved using original data sheets or through discussions with Field Crew Leaders. Documentation of changes was maintained for most editing activities.

Automated review procedures such as range checks, frequency distribution of coded variables, and other internal consistency checks were designed by Versar, Inc., and employed for data entry verification.

For the 2001 MBSS, all data discrepancies were documented and resolved by DNR and Versar staff prior to data analysis.

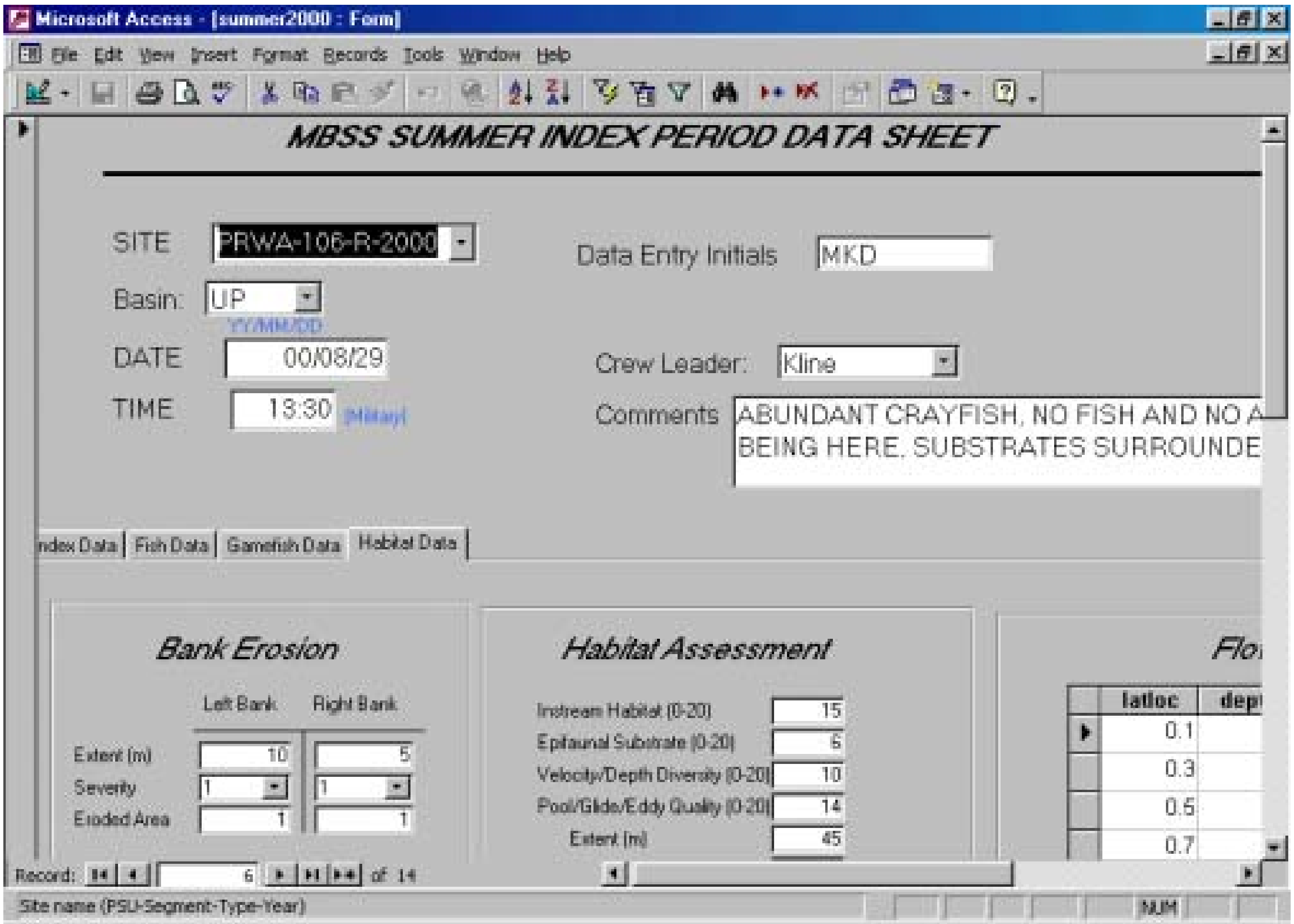

Figure 7-1. Example of MBSS data entry program in Microsoft Access

8 DATA ACQUISITION AUDITS

Even though a sophisticated survey design and rigorous sampling methods have been developed for the MBSS, the quality of the data still depends to a large degree on how well the data acquisition is accomplished. To foster high quality implementation and obtain more information on how variation in method use affects results, field audits were conducted.

8.1 FACILITIES AND EQUIPMENT

Preventive maintenance and calibration are performed on all sampling equipment used as part of the MBSS program. According to the MBSS Sampling Manual (Kazyak 2000, 2001), maintenance and calibration procedures are implemented as per manufacturers instructions. For each crew, the turbidity meter and hydrolab are calibrated daily, and the flowmeter and scale calibrated at least once a week. Calibration is also performed any time equipment problems are suspected. Preventative maintenance is performed at intervals that meet the frequency recommended by the manufacturer. All equipment malfunctions should be fully corrected prior to reuse. For each piece of equipment used as part of the MBSS, a bound logbook for calibration and maintenance is maintained. Entries in the log are made for all calibration and maintenance activities. Documentation includes detailed descriptions of all calibrations, adjustments, and replacement of parts, and each entry is signed and dated. To ensure that MBSS equipment is operated within QA/QC requirements, the QC Officer conducts several site equipment audits per year.

During MBSS 2001 sampling, according to each crew leader, logbooks were maintained that documented all calibration and maintenance activities. All three crew leaders provided copies of their logbooks documenting that daily calibration of both the turbidity meter and hydrolab and regular calibration of the scale and flowmeter. However some important calibrations were missing. One of the crews was unable to produce turbidity and hydrolab calibration logs for one week of the sampling season, and also lacked documentation for five weeks of scale and flowmeter calibrations. Another crew missed two separate weeks of flowmeter calibration. The remaining crew missed no calibrations.

8.2 SAMPLING AUDITS

All of the standard operating procedures outlined in the MBSS sampling manual (Kazyak 2001) are intended to be strictly followed. To ensure that all procedures were properly implemented, the QC Officer conducted 19 crew audits in the field. Each audit included several or all of the following:

- a determination of correctness in locating the sampling segment using GPS equipment;
- assessment of acceptability for sampling;
- evaluation of the preparation and planning prior to field sampling;
- adherence to sampling protocols;
- field technique evaluations;
- verification of taxonomic identifications;
- checks for completeness of data sheets and field notebooks;
- equipment calibration and maintenance log review;
- a health and safety critique of crew activities; and
- data transcription.

Notes on all audits were maintained by the QC Officer and corrective actions were discussed with the Crew Leader as needed.

9 DATA QUALITY ASSESSMENT

This section describes the results of the QA/QC activities, including audits described above and evaluations of the quality of the data obtained in the MBSS 2001 sampling. Separate subsections address water quality, benthic, fish, herpetofauna, aquatic vegetation, and physical habitat data. Where appropriate, both field and laboratory analysis aspects are discussed.

9.1 WATER QUALITY SAMPLING

For MBSS 2001, a review of laboratory and field records and interviews with field crew leaders confirmed that water quality samples were collected according to protocols, samples and custody sheets were properly labeled, and proper sample preservation methods were followed.

9.1.1 Field Collections

Following the standard methods in the MBSS Sampling Manual (Kazyak 2001), water quality variables were measured in situ or were collected in the field and sent to University of Maryland's Appalachian Laboratory in Frostburg for analysis. Grab samples were collected in 0.5 and 1-liter bottles for analysis of all analytes except pH. Water samples for pH were collected with 60 ml syringes, which allowed purging of air bubbles to minimize changes in carbon dioxide content.

Because of practical and cost constraints, MBSS 2001 water quality samples were stored on wet ice and generally shipped to the University of Maryland's Appalachian Laboratory in Frostburg within 48 hours. This resulted in an exceedance of the 24 hour filtering time limit for some analytes and samples. Lab experience has shown that exceeding filtering time limits for surface waters has a negligible effect on results (Ray Morgan, Appalachian Laboratory, pers. comm.).

During the spring index period, water samples were collected in the field and analyzed in the laboratory for pH, specific conductance, acid neutralizing capacity (ANC), chloride, nitrate-nitrogen, sulfate, total dissolved phosphorus (TDP), ortho-phosphate, nitrite-nitrogen, ammonia, total dissolved nitrogen (TDN), and dissolved organic carbon (DOC). Variables measured in the field during the summer index period included temperature, dissolved oxygen, pH, and conductivity.

Two types of QC samples for water chemistry are obtained during each sampling year of the MBSS. One QC sample per crew is a blank, while at 5% of the sites, duplicate water samples are obtained and sent to the laboratory for analysis with the other samples from that site. According to protocol, duplicate water quality samples were obtained at 5% (11) of the sites.

9.1.2 Laboratory Analysis

The complete report *Quality Assurance/Quality Control Results from Spring 2001 Water Quality Chemistry Analysis for the Maryland Biological Stream Survey*, prepared by Appalachian Laboratory analysts, is presented in Appendix B. This section presents excerpts from their report.

To ensure attainment of the quality assurance objectives, standard operating procedures were implemented that include requirements for the correct performance of analytical or laboratory procedures. The quality of all data generated and processed during the spring 2001 MBSS was monitored for both precision and accuracy. The internal QA/QC protocols for chemical analysis followed guidelines from the *Handbook of Methods for Acid Deposition Studies: Laboratory Analyses for Surface Water Chemistry* (U.S. EPA 1987).

9.1.2.1 Precision

The precision of the water quality results was determined by measuring the agreement among individual measurements of the same property, under similar conditions. Precision was assessed through the analysis of laboratory duplicates or splits. The degree of agreement between replicates can be expressed as the percent relative standard deviation (RSD):

$$\text{Percent RSD} = \frac{SD}{\bar{x}} \times 100$$

Table 9-1 presents the results of the laboratory duplicate analyses and indicates that each analyte was well within its respective acceptable precision limits.

9.1.2.2 Accuracy

Accuracy is defined as a measure of the closeness of an individual measurement to the true or expected value. Analyzing a reference material or quality control check solution (QCCS) of known concentration is a method of determining accuracy. QCCSs were independently made and analyzed after calibration, at specified intervals during sample analysis and at the conclusion of sample analysis, to ensure accurate measurement throughout analysis. Table 9-2 presents the results of the QCCS analysis. The mean value for each analyte was within the acceptable range of accuracy. Some of the minimum and maximum values for Sulfate, ANC, ortho-phosphate, ammonia, TDP, and DOC were outside the acceptable range. If the QCCS was not within the acceptable range, the solution was remade and analyzed again. If it failed to pass the second time, the meter was re-calibrated and all samples that were measured since the last acceptable QCCS were re-analyzed.

9.1.2.3 Laboratory Blanks

Deionized water blanks served as a check of laboratory-induced contamination. Laboratory blanks were analyzed at predetermined intervals as outlined in the standard operating procedures for each analyte. Table 9-3 presents the results of the laboratory blank analyses and indicates that the mean concentration for each analyte was within the acceptable range. A few of the analytes, pH, ortho-phosphate, TDP, and DOC had maximum concentrations that exceeded their respective acceptable limits.

Deionized water blanks were taken at three sites in order to serve as field blanks. Results are summarized in Table 9-4. Results fell into acceptable ranges for field blank analyses.

9.1.2.4 Sample Spikes

Sample spikes were used with most of the analytical techniques to determine whether the sample matrix affected analytical accuracy. A known concentration of analyte was added to about 15% of the samples. Both the spiked and unspiked samples were then analyzed. Percent recovery was calculated using the following equation:

$$\text{\% Spike recovery} = \frac{\text{spiked sample - routine sample}}{\text{spike amount (mg/L)}} \times 100\%$$

Percent recovery calculated for sample spikes should be within 15% of 100%. Table 9-5 presents the percent recovery results and indicates that the mean concentration was well within the 15% recovery rate.

Table 9-1. Summary of precision analysis for MBSS 2001 water quality laboratory duplicates. Average precision values are given as percent relative standard deviation (% RSD) unless otherwise noted.

Analyte	Average Precision	Acceptable Precision	N	Std. Dev.
Closed pH	0.007 units	0.10	37	0.04
ANC (µeq/l)	0.9	10	37	1.12
Conductance	0.45	3	34	0.52
Chloride	0.51	5	42	0.85
Nitrate-Nitrogen	1.14	5	42	1.79
Sulfate	0.61	5	44	0.76
Nitrite-Nitrogen (mg/l)	0.0001 mg/l	0.05	70	0.001
Ortho-phosphate (mg/l)	0.0003 mg/l	0.05	70	0.001
Ammonia (mg/l)	0.003 mg/l	0.05	70	0.022
TDN	2.67	5	75	2.42
TDP	4.04	5	66	4.80
DOC	4.2	10	79	4.48

Table 9-2. Summary of QCCS analysis.							
Analyte	**Theoretical Value**	**Acceptable Accuracy Range**	**Mean**	**N**	**Std. Dev.**	**Min.**	**Max.**
Closed pH	5.00	± 0.05	5.00	79	0.02	4.96	5.03
ANC (μeq/l)	200.0	± 10	194.3	29	5.38	186.5	211.5
	50.0	± 10	47.5	4	1.93	46.0	50.3
Conductance (μS/cm)	14.7	± 1.5	15.4	18	0.27	15.0	16.0
	74.0	± 4	75.9	19	1.16	74.1	77.8
	147.0	± 7.4	149.4	19	4.55	137.8	153.8
Chloride (mg/l)	1.0	± 0.2	.996	62	0.05	0.90	1.18
Nitrate-Nitrogen (mg/l)	0.5	± 0.2	0.500	62	0.02	0.48	0.64
Sulfate (mg/l)	2.0	± 0.2	1.918	62	0.01	1.77	2.13
Nitrite-Nitrogen (mg/l)	0.05	± 0.01	0.049	86	0.002	0.041	0.057
Ortho-phosphate (mg/l)	0.05	± 0.01	0.048	86	0.003	0.039	0.055
Ammonia (mg/l)	0.05	± 0.01	0.051	86	0.002	0.046	0.057
TDN (mg/l)	0.20	± 0.05	0.202	125	0.016	0.166	0.242
TDP (mg/l)	0.10	± 0.01	0.094	89	0.004	0.084	0.102
DOC (mg/l)	10.0	± 0.5	9.867	111	0.333	9.341	10.663
	2.0	± 0.2	2.018	111	0.148	1.729	2.442

Table 9-3. Summary of laboratory blank analyses.						
Analyte	**Mean**	**Acceptable Range**	**N**	**Std. Dev.**	**Minimum**	**Maximum**
Closed pH	5.54	5.40 - 6.00	29	0.15	5.37	6.04
ANC (μeq/l)	0.48	< 10	23	3.89	-6.28	9096
Conductance (μS/cm)	0.58	< 1 μS/cm	16	0.17	0.37	0.87
Chloride (mg/l)	0	< 0.01	15	0	0	0
Nitrate-Nitrogen (mg/l)	0	< 0.01	15	0	0	0
Sulfate (mg/l)	0	< 0.01	15	0	0	0
Nitrite-Nitrogen (mg/l)	0.0001	< 0.005	24	0.001	-0.001	0.003
Ortho-phosphate (mg/l)	0.0002	< 0.005	24	0.002	-0.005	0.007
Ammonia (mg/l)	-0.0009	< 0.010	24	0.003	-0.012	0.008
TDN (mg/l)	-0.015	< 0.5	51	0.053	-0.266	0.121
TDP (mg/l)	0.003	< 0.005	17	0.002	0.002	0.006
DOC (mg/l)	0.078	< 0.2	31	0.177	0.565	0.486

Table 9-4. Summary of field blank analyses			
Analyte	**Field Blank Value 1**	**Field Blank Value 2**	**Field Blank Value 3**
Closed pH	5.55	5.78	6.21
ANC (μeq/l)	-1.40	-1.30	-1.10
Conductance (μS/cm)	1.29	1.09	0.80
Chloride (mg/l)	.226	0.230	0
Nitrate-Nitrogen (mg/l)	0.001	0.001	0.01
Sulfate (mg/l)	0.010	0.010	0.010
Nitrite-Nitrogen (mg/l)	0.0004	0.0004	0.0004
Ortho-Phosphate (mg/l)	0.0007	0.0007	.0007
Ammonia (mg/l)	0.002	0.002	0.002
TDN (mg/l)	0.125	0.125	0.125
TDP (mg/l)	0.0037	0.0037	0.0037
DOC (mg/l)	0.157	0.230	-0.239

Table 9-5. Summary of percent recovery results from sample spike analysis.					
Analyte	**Mean**	**N**	**Std. Dev.**	**Minimum**	**Maximum**
Nitrite-Nitrogen	101.3	25	3.3	92.9	108.1
Ortho-phosphate	103.2	25	6.7	86.3	109.1
Ammonia	104.7	25	4.5	94.5	119.0
Chloride	102.0	27	7.1	84.5	118.5
Nitrate-Nitrogen	99.5	28	15.9	87.0	115.3
Sulfate	95.5	30	12.6	118.9	103.8
TDN	98.6	11	8.5	85.3	110.5
TDP	99.3	18	3.2	91.8	107.2

9.1.2.5 Collection and Analysis of Natural Audit Sample

Natural audit samples are another useful part of a comprehensive quality assurance assessment. Because they are collected from streams, they are more representative of the actual sample matrix than a manufactured calibration check solution. In January of 1997, a field natural audit sample was collected from Upper Big Run in the Savage River State Forest in order to establish an internal audit sample (FNBR001). Approximately 50 liters of sample were filtered using a 0.45 μm filter capsule and a Masterflex pump. The sample was returned to the Appalachian Laboratory where it was refrigerated for approximately 20 days and periodically checked for stability by analyzing sample ANC. Once the sample was stable, it was poured off into 500 mL aliquots. The audit samples are stored in the dark at 4 ˚C and are analyzed periodically for all analytes except closed pH and aluminum. Although there are no actual correct or incorrect results for any of the analytes, as when a known QCCS is measured, variations in analyte concentration can help determine or diagnose any sources of analytical error. They are especially useful as a diagnostic tool when there are any changes in the operating conditions of an instrument (i.e., column or electrode replacement). The results from the analysis of the audit samples verified the stability of the analytical results as the mean and standard deviations were similar to what Appalachian Laboratory staff typically observe (Table 9-6).

9.1.2.6 Field Duplicates

In the spring index period, 213 sites were sampled for water quality. Field duplicates were obtained from eleven sites (5%). Precision of the duplicate samples was determined by measuring the Relative Percent Difference (RPD).

$$RPD = (|X1-X2|*100)/((X1+X2)/2)$$

Lower RPDs indicate greater precision, therefore, nitrite (0% RPD) and chloride (0.27% RPD), which had the lowest RPDs, are considered to have the greatest precision (Table 9-8).

Twenty percent RPD was selected as a general “rule of thumb” threshold for evaluating precision within pairs of samples. Two analytes, PN and PP, had the greatest number of paired samples with RPDs greater than 20% and only ortho-phosphate had a median RPD greater than 20% (Table 9-7).

Table 9-6. Natural audit sample analytical results.					
Analyte	**Mean**	**N**	**Std. Dev.**	**Minimum**	**Maximum**
ANC	35.0	27	4.44	29.0	46.3
Conductance	30.0	8	0.46	29.5	30.6
Chloride	0.915	13	0.03	0.862	0.988
Nitrate-Nitrogen	0.150	13	0.04	0.085	0.189
Sulfate	6.812	13	0.06	6.660	6.943
DOC	0.660	10	0.05	0.585	0.723

Table 9-7. Summary of field duplicate RPD results (n = 11 pairs)			
Analyte	**Pairs of Samples with RPD > 20%**	**Percent of Pairs of Samples with RPD > 20%**	**Median RPD**
PH	0	0%	0.56
Conductance	0	0%	0.19
ANC	0	0%	0.39
Chloride	0	0%	0.81
Nitrate-Nitrogen	0	0%	0.72
Sulfate	0	0%	0.81
TDP	1	9%	5.61
Ortho-phosphate	7	64%	38.44
Nitrite-Nitrogen	4	36%	11.32
Ammonia	5	45%	8.00
TDN	1	9%	2.58
DOC	0	0%	3.83

9.2 BENTHIC SAMPLING

9.2.1 Field Collections

Following the method detailed in Kazyak (2001), within each sample segment MBSS 2001 benthic samples were collected in areas most likely to support the greatest benthic taxonomic diversity, preferably in riffle areas, but also in other habitat types. A 600 micron mesh D-net was used to collect the sample. Each "jab" of the D-net covered one square foot of area, and a total of approximately 2.0 square meters (20 square feet) per site was sampled and preserved in 70% ethanol.

The index period for benthic sampling occurs between March 1 and May 1, with the end of the index period being determined by degree-day accumulation as specified in Hilsenhoff (1987). For the 2001 field season, all benthic sampling occurred during this index period, with the first samples taken on March 1, 2001 and the last samples taken on March 29, 2001. Also, during the 2001 field season, it was noted that there were no problems with the labeling and preservation of the benthic samples.

Duplicate field samples were taken at 19 sites (7% of all sites sampled) during the 2001 sampling. These duplicates were taken in the same segment at the same time as time as the original sample and preserved in separate bottles to be sent to the laboratory and identified. To determine the replicability of the benthic IBI score and its component metrics, the benthic IBI analysis was run on the duplicate samples taken at each of these sites. Table 9-8 shows a comparison of duplicate sample results for each site. Table 9-9 shows result of further analyses of differences in benthic IBI scores and individual metrics.

At these 19 sites, the mean benthic IBI for the original data was 3.75, while the mean for the duplicate data was 3.38. This result was not significantly different (p value 0.47, paired t-test). The R^2 of the linear regression was 0.80 and the CV for the benthic IBI was 0.10, comparable to the results for duplicate sites sampled in the first round of the MBSS (CV of 0.08, Roth et al. 2001b) and the results reported in the MBSS 2000 QA report (Mercurio et al. 2001). The median RPD was 14.21 and three sites had an RPD greater than 20%. These results indicate that there is generally little difference between duplicate samples taken at the same site.

For the three metrics that the Coastal Plain and non-Coastal Plain IBIs have in common (Number of Taxa and Number of EPT taxa, and Percent Ephemeroptera), the R^2 of a linear regression between the original data and the field duplicates ranged between 0.51 and 0.92. The mean Coefficient of Variation (CV; the ratio of the standard deviation to the mean) for individual metrics varied from 0.15 to 0.29, while the median Relative Percent Difference (RPD; see Section 9.1) varied from 13.33% to 28.05%. From seven to nine sites had an RPD greater than 20%. These results are consistent with those reported in the MBSS 2000 QA document.

Four metrics apply only to the Coastal Plain, where 12 duplicate sites were sampled in 2001**.** For these metrics (Percent Tanytarsini of Chironomidae, Beck's Biotic Index, Number of Scraper Taxa, and Percent of Clingers), the R^2 of the linear regression analysis ranged between 0.46 and 0.83. The CV varied between 0.27 and 0.58. The median RPD (excluding the sites with one value of zero for the metric in question) for these metrics varied from 28.57 to 58.17 and from five to ten sites had RPD values greater than 20%. These results are also consistent with results reported in the MBSS 2000 QA document.

The remaining six metrics apply to only the sites in the non-Coastal Plain region of the state (n=7 pairs of duplicates). For these metrics (Number of Ephemeroptera Taxa, Number of Diptera Taxa, Percent Tanytarsini, Number of Intolerant Taxa, Percent Tolerant Taxa, and Percent Collectors), the R^2 of the linear regression analysis varied from 0.65 to 0.90. The CV varied from 0.10 to 0.59 and the median RPD varied from 3.51 to 34.94. From two to five sites had an RPD greater than 20%. Again, these results are consistent with those reported in the MBSS 2000 QA report.

Taxa lists for the original and duplicate samples were also examined in order to look for differences in what taxa were sampled in the same 75-m segment. These lists, with the percent contribution of each taxon to the total number of individuals found in the sample, can be found in Appendix C. In 15 of the 19 sites (79%) where field duplicates were taken, the same taxon made up the greatest proportion of individuals in both the original data and in the duplicate data. Overall, there was a high degree of similarity in the taxa found in the original and in the duplicate, although there were some discrepancies that can be attributed to both differences in field collection procedures and in laboratory subsampling and identification. The rarest taxa in each sample (those with only one or two individuals in a sample) were the taxa mostly likely to vary the greatest between the original data and the subsample. To isolate differences that result from laboratory subsampling (i.e., selection of a 100-organism subsample from the full sample collected), a separate set of benthic laboratory duplicates was analyzed, as described below.

9.2.2 Laboratory Sampling

MBSS benthic samples are shipped to the DNR field office and assigned an unique sample log number. Sample buckets are checked for adequate quantities of preservatives and for cracks or poorly fitted lids. Samples are stored in an area with good ventilation until processed. The preserved sample is then transferred to a gridded pan and organisms are picked from randomly selected grid cells until the cell that contains the 100th individual (if possible) is completely picked. Some samples may have fewer than 100 individuals. For the MBSS, benthic macroinvertebrates are identified to genus, or the lowest practicable taxonomic level. Questionable identifications are verified by consulting DNR benthic taxonomists, regional experts, and regional keys for certain taxonomic groups. A complete description of laboratory protocols can be found in Boward and Friedman (2000).

Table 9-8. Summary data for field replicate composite samples at 19 randomly selected 2001 MBSS stream segments. Score 1 and Score 2 represent rating categories assigned based on IBI (1= very poor, 2 = poor, 3 = fair, 4 = good)

Site	Original BIBI	Duplicate BIBI	Difference	Mean	Standard Deviation	Coefficient of Variation	Score 1	Score 2
BALT-207-R-2001	2.43	2.71	-0.29	2.57	0.20	0.08	2	2
DEER-106-R-2001	2.78	1.44	1.33	2.11	0.94	0.45	2	1
DIVI-111-R-2001	3.57	2.71	0.86	3.14	0.61	0.19	3	2
GILB-109-R-2001	1.86	1.86	0.00	1.86	0.00	0.00	1	1
LIGU-201-R-2001	4.33	3.67	0.67	4.00	0.47	0.12	4	3
NEWP-110-R-2001	1.29	1.57	-0.29	1.43	0.20	0.14	1	1
PAXM-107-R-2001	1.86	1.86	0.00	1.86	0.00	0.00	1	1
PRAL-208-R-2001	3.44	3.67	-0.22	3.56	0.16	0.04	3	3
SENE-114-R-2001	2.56	2.11	0.44	2.33	0.31	0.13	2	2
STIL-109-R-2001	2.43	2.71	-0.29	2.57	0.20	0.08	2	2
UPPC-101-R-2001	1.29	1.57	-0.29	1.43	0.20	0.14	1	1
WEBR-106-R-2001	1.86	2.14	-0.29	2.00	0.20	0.10	1	2
YOUG-101-C-2001	4.56	4.11	0.44	4.33	0.31	0.07	4	4
YOUG-106-R-2001	3.67	3.89	-0.22	3.78	0.16	0.04	3	3
YOUG-221-R-2001	4.78	4.78	0.00	4.78	0.00	0.00	4	4
ZEKI-103-R-2001	2.71	2.14	0.57	2.43	0.40	0.17	2	2
ZEKI-215-R-2001	4.14	4.43	-0.29	4.29	0.20	0.05	4	4
ZEKI-302-R-2001	3.57	3.86	-0.29	3.71	0.20	0.05	3	3
ZEKI-307-R-2001	3.86	4.14	-0.29	4.00	0.20	0.05	3	4

Table 9-9. Benthic IBI component metrics and final score comparisons for the 19 duplicate field samples taken during the 2001 MBSS							
Metric	**N***	**R^2**	**Mean Original Sample**	**Mean Duplicate Sample**	**Mean CV**	**Median RPD**	**Number of Sites with RPD > 20%**
Number of Taxa	19	0.51	22.53	23.05	0.15	13.33	7
Number of EPT Taxa	19 (18)	0.91	7.37	6.79	0.28	23.04	9
Percent Ephemeroptera	19 (10)	0.92	9.29	9.76	0.59	28.05	7
Percent Tanytarsini of Chironomidae	12 (6)	0.79	11.81	10.30	0.58	58.17	6
Beck's Biotic Index	12	0.46	4.00	4.42	0.40	34.29	10
Number of Scraper Taxa	12 (8)	0.76	1.92	2.08	0.43	28.57	5
Percent of Clingers	12	0.83	43.10	38.01	0.27	30.00	7
Number of Ephemeroptera	7 (6)	0.90	19.71	20.29	0.43	34.94	4
Number of Diptera	7	0.65	11.86	12.00	0.12	16.67	2
Percent Tanytarsini	7 (5)	0.96	5.26	5.24	0.59	3.51	2
Number of Intolerants	7	0.66	7.57	6.29	0.20	11.76	2
Percent Tolerant	7	0.87	26.93	30.75	0.28	31.16	5
Percent Collectors	7	0.79	32.48	35.71	0.20	29.92	4
Benthic IBI	19	0.80	3.73	3.38	0.10	14.21	3
* Values in parentheses indicate the number of sites used in the RPD analysis when the sites containing one value of zero were excluded from the analysis							

Using the unique log numbers, approximately every 20th sample is randomly chosen for re-subsampling and identification. Each sample is subsampled and identified as usual, except that chironomids are identified to subfamily or tribe (eliminating the need to slide mount the larvae of this family). The identified organisms are returned to the sample bucket and the bucket is re-subsampled. This second subsample is identified according to standard procedures and comparisons are made between the two duplicates.

In the 2001 MBSS, 13 samples were chosen for this QC analysis. Because taxa in the duplicate subsample were identified to higher taxonomic levels than taxa in the original sample, taxa in the original were also grouped up to these higher levels. The benthic IBI analysis was run on these new taxa lists and individual metrics were compared as in the analysis of the field duplicates above. Tables 9-10 and 9-11 show the results of this analysis.

Table 9-10. Summary data for laboratory replicate composite samples at 13 randomly selected 2001 MBSS stream segments. Score 1 and Score 2 represent rating categories assigned based on IBI (1= very poor, 2 = poor, 3 = fair, 4 = good)								
Site	**Original**	**Duplicate**	**Difference**	**Mean**	**Standard Deviation**	**Coefficient of Variation**	**Score 1**	**Score 2**
BALT-202-R-2001	2.14	2.43	-0.29	2.29	0.20	0.09	2	2
GILB-114-R-2001	2.43	2.14	0.29	2.29	0.20	0.09	2	2
NASS-217-R-2001	3.57	4.14	-0.57	3.86	0.40	0.10	3	4
NEAS-201-R-2001	3.22	3.67	-0.44	3.44	0.31	0.09	3	3
PAXM-119-R-2001	2.14	1.86	0.29	2.00	0.20	0.10	2	1
PRET-111-R-2001	3.67	4.11	-0.44	3.89	0.31	0.08	3	4
PRUN-103-R-2001	3.67	3.44	0.22	3.56	0.16	0.04	3	3
SAVA-101-R-2001	4.78	4.78	0.00	4.78	0.00	0.00	4	4
SENE-205-R-2001	3.00	3.22	-0.22	3.11	0.16	0.05	3	3
UPPC-103-R-2001	2.14	1.86	0.29	2.00	0.20	0.10	2	1
WEBR-212-R-2001	1.57	2.14	-0.57	1.86	0.40	0.22	1	2
YOUG-110-R-2001	2.56	2.56	0.00	2.56	0.00	0.00	2	2
ZEKI-307-R-2001	3.86	3.86	0.00	3.86	0.00	0.00	3	3

Table 9-11. Benthic IBI component metrics and final score comparisons for the 13 duplicate lab samples taken during the 2001 MBSS

Metric	N*	R^2	Mean Original Sample	Mean Duplicate Sample	Mean CV	Median RPD	Number of Sites with RPD > 20%
Number of Taxa	13	0.29	20.31	18.15	0.14	16.21	5
Number of EPT Taxa	13	0.85	6.08	6.92	0.24	33.33	10
Percent Ephemeroptera	13 (12)	0.97	14.60	14.37	0.48	11.58	4
Percent Tanytarsini of Chironomidae	7 (6)	0.96	15.40	14.21	0.53	16.87	2
Beck's Biotic Index	7 (6)	0.18	3.43	3.71	0.59	66.67	5
Number of Scraper Taxa	7 (5)	0.17	1.29	1.14	0.75	66.67	3
Percent of Clingers	7 (6)	0.94	29.84	24.51	0.54	60.64	4
Number of Ephemeroptera	6 (5)	0.99	28.33	32.33	0.46	22.22	3
Number of Diptera	6	< 0.1	8.67	7.50	0.13	17.78	3
Percent Tanytarsini	6	0.46	7.95	7.57	0.51	79.29	5
Number of Intolerants	6 (5)	0.76	4.17	5.00	0.45	22.22	3
Percent Tolerant	6	0.92	10.16	9.07	0.29	20.56	3
Percent Collectors	6	0.90	50.92	47.48	0.08	6.42	1
Benthic IBI	13	0.89	2.98	3.09	0.07	12.5	1

* Values in parentheses indicate the number of sites used in the RPD analysis when the sites containing one value of zero were excluded from the analysis

Although a true benthic IBI can not technically be calculated for these duplicate data because of the lumping of the chironomid taxa, a hypothetical IBI was calculated and the results of the original sample were compared with the results from the duplicate sample. At the 13 sites where laboratory duplicates were taken, the mean benthic IBI for the original data was 2.98, while the mean for the duplicate data was 3.09. This result is not statistically significant (p value 0.24 paired t test). The R^2 of the linear regression was 0.89 and the CV was 0.07. The median RPD was 12.50 and only one site had an RPD greater than 20%. These results indicate that although there is variation between duplicates in the individual metrics that make up the benthic IBI, this variation does not dramatically affect the final IBI score.

For the three metrics that the Coastal Plain and non-Coastal Plain IBIs have in common (Number of Taxa and Number of EPT taxa, and Percent Ephemeroptera), the R^2 of a linear regression between the original data and the field duplicates ranged between 0.29 and 0.97. The CV varied from 0.14 to 0.48, while the median Relative Percent Difference (RPD; see Section 8.1) varied from 11.58% to 33.33%. From four to ten sites had an RPD greater than 20%. These results are comparable with those reported in the MBSS 2000 QA report.

Four metrics apply only to the seven Coastal Plain sites that were sampled in 2001. For these metrics (Percent Tanytarsini of Chironomidae, Beck's Biotic Index, Number of Scraper Taxa, and Percent of Clingers), the R^2 of the linear regression analysis ranged between 0.17 and 0.96. The CV varied between 0.53 and 0.75. The median RPD (excluding the sites with one value of zero for the metric in question) for these metrics varied from 16.67 to 66.67 and from two to five sites had RPD values greater than 20%. While the R^2 values are slightly lower and the mean CV and median RPD are slightly higher, these values are still comparable to those reported in the MBSS 2000 QA report.

The remaining six metrics apply to only the six sites in the non-Coastal plain region of the state. For these metrics (Number of Ephemeroptera Taxa, Number of Diptera Taxa, Percent Tanytarsini, Number of Intolerant Taxa, Percent Tolerant Taxa, and Percent Collectors), the R^2 of the linear regression analysis varied from < 0.01 to 0.99. The CV varied from 0.08 to 0.51 and the median RPD varied from 6.42 to 79.29. From one to five sites had an RPD greater than 20%. These values are also consistent with those reported in the MBSS 2000 QA report.

Taxa lists for the original and duplicate subsamples were also examined in order to look for differences in what taxa were randomly picked from the sampling grid. These lists, with the percent contribution of each taxon to the total number of individuals found in the subsample, can be found in Appendix D. In 10 of the 13 sites (77%) where laboratory duplicates were taken, the same taxon made up the greatest proportion of individuals in both the original data and in the duplicate data. Overall, there was a high degree of similarity in the taxa found in the original and in the duplicate, although the random nature of the subsampling process leads to inherent differences in the taxa being included in these lists.

9.3 FISH SAMPLING

According to MBSS protocols, fish are sampled during the summer index period from June 1 and September 30 (Kazyak 2001). Fish are sampled using double-pass electrofishing within 75-meter stream segments. Block nets are placed at each end of the segment and direct current backpack electrofishing units are used to sample the entire segment. Any individual fish that cannot be identified should be retained for laboratory confirmation. In addition, 10 voucher specimens of each species will be retained for each major (Maryland 6-digit) drainage basin during the 2000-2004 MBSS.

During MBSS 2001, 70,327 individual fish representing 74 species and 3 genera (not initially identifiable to species) were sampled in the field. Following MBSS protocols (Kazyak 2001), most fish were identified in the field and released. When field crew leaders were uncertain of identification, a "best guess" name was recorded and the individual was retained for laboratory identification. Laboratory identification can serve to distinguish between two closely related species, particularly when features not easily observed in the field provide the needed evidence for positive identification. In other cases (e.g., *Lepomis* hybrids), the expertise of an ichthyologist specialist aids in hybrid confirmation.

All voucher specimens and fish retained for positive identification were examined and verified by Dr. Rich Raesly, an ichthyologist at Frostburg State University, Frostburg, Maryland. All MBSS collections are archived in the fish museum at Frostburg State University.

Four specimens at 4 sites were initially identified incorrectly in the field but retained for correct identification. One small *Noturus gyrinus* individual had been incorrectly identified as *Noturus insignis* (one site). *Clinostomus funduloides* had been incorrectly identified as a Cyprinid hybrid (1 fish at 1 site). *Rhinichthys cataractae* (1 fish at 1 site) was incorrectly identified as *Rhinichthys atratulus*, and one individual of an initially undetermined species was incorrectly identified as *Pimephales promelas*. Five species at 6 sites were identified only to genus in the field, but retained. *Petromyzon marinus* (2 fish at 1 site) were identified as Unknown Lamprey. *Enneacanthus gloriosus* (85 fish at 2 sites), and *Enneacanthus obesus* (36 fish at 2 sites) had been identified as Enneacanthus sp. *Notropis rubellus* (7 fish at 2 sites), and *Notropis amoenus* (2 fish at 2 sites) had been identified as Notropis sp. After positive identification was made by Dr. Raesley, all appropriate modifications were made to the data sets prior to analysis and reporting. Two species at 2 sites were misplaced in different containers during the sampling season. They were placed in the correct containers after Dr. Raesley discovered the mistake.

Over time the MBSS is establishing a voucher collection of fish as a long-term archive. During each round of sampling, the goal is to archive 10 individuals of each species per 6-digit basin. During MBSS 2001, 10 individuals per species were not sampled in every basin and, therefore, could not be retained. For each 6-digit basin, there were a number of species where the number of individuals sampled exceeded 10, but where the number of voucher specimens retained was less than 10, or when the number of individuals sampled was less than 10, fewer individuals than the number sampled were retained. Appendix E presents a table of fish species by the number that were sampled and the number that were retained in each 6-digit basin. None of the six species in the North Branch Potomac River basin were retained for voucher specimens. It is important to note there are three more years in the second round of the MBSS to obtain at least 10 individuals per species in each basin.

9.4 HERPETOFAUNA SAMPLING

At each segment sampled during the MBSS 2001 summer index period, amphibians and reptiles encountered during the course of electrofishing and other activities were captured, identified, and recorded. Individuals were identified to species when possible. Voucher specimens of adults were retained for each species new to each 6-digit drainage basin; larval salamanders and tadpoles were not retained. Amphibians and reptiles encountered and positively identified during spring index period sampling were recorded in the notes section of the data sheets.

9.5 AQUATIC VEGETATION SAMPLING

During the summer index period, aquatic vegetation was sampled qualitatively by examining each 75-meter stream segment for the presence of aquatic plants. The presence and relative abundance of submerged, emergent, and floating aquatic vegetation were recorded. Because there is no practical, easy way to preserve aquatic vegetation, taxonomic identification was made optional for the 2000-2004 MBSS. No quality assurance was performed for aquatic vegetation sampling.

9.6 PHYSICAL HABITAT SAMPLING

9.6.1 Spring Index Period

Physical habitat assessments are conducted during both spring and summer index periods. Following the MBSS Sampling Manual protocols (Kazyak 2001) for the spring, riparian zone vegetation type is noted and width on each bank is estimated to the nearest meter (up to 50 meters from the stream). The severity and type of buffer breaks, local land use type, and extent and type of stream channelization are recorded. Altitude and stream gradient are measured. Crews also record distance from road and assign an aesthetic rating (based on visible signs of human refuse at a site) to characterize human presence. The QC Officer makes independent habitat assessments of approximately 10% of the total number of sites sampled during the spring index period.

During the 2001 spring index period, the QC Officer conducted habitat assessments at 18 sites (approximately 8% of the 212 sites sampled). Most of the habitat data obtained during the spring index period is qualitative. Overall, there is good correspondence between the QC Officer's and field crews' qualitative data (Table 9-12). There were six variables (left and right bank buffer break presence, left and right bank dominant vegetation type, wetland presence, and cropland presence) that were in disagreement at more than 20% of the sites. In most cases, the differences were due to very similar abundances of different types of bank vegetation, in which case either of the vegetation types could be considered dominant. For example, at station NEWP-110-R-2001, the crew selected young deciduous trees as the dominant vegetation and shrubs as the second most abundant, while the QC Officer selected shrubs as the dominant vegetation and young deciduous trees as second most abundant type.

There were 23 quantitative variables measured or estimated during the spring index period: distance from road; aesthetic rating; altitude; width of riparian vegetation on left and right bank; extent of concrete, gabions, riprap, berm, pipe, and dredge spoil; channelization on left and right bank, and bottom of channel. Since there were no records of gabion in 2001, it does not appear in the table below. Table 9-13 shows a general correspondence between the sampling crews and QC Officer's data, even though some of these values (e.g., distance from road) are estimated visually rather than actually measured. However, for some of the estimated variables differed greatly, such as extent of dredged channel, where the sampling crews recorded 75m and the QC Officer 0m at one station.

Table 9-12. Comparison of spring habitat qualitative results between sampling crews and QC Officer.

Variable	# Samples Different	Total # of Samples	% of Samples Different
Adjacent cover - left bank	2	16	13%
Adjacent cover - right bank	2	16	13%
Buffer breaks - left bank	4	16	25%
Buffer breaks - right bank	5	16	31%
Vegetation type 1- left bank	8	14	57%
Vegetation type 1- right bank	9	15	60%
Old field presence (Y/N)	2	18	11%
Deciduous forest presence (Y/N)	1	18	6%
Coniferous forest presence (Y/N)	1	18	6%
Wetland presence (Y/N)	5	18	28%
Surface mine presence (Y/N)	0	18	0%
Landfill presence (Y/N)	0	18	0%
Residential land presence (Y/N)	3	18	17%
Commercial/Industrial land presence (Y/N)	0	18	0%
Cropland presence (Y/N)	5	18	28%
Pasture presence (Y/N)	1	18	6%
Orchard/Vineyard/Nursery presence (Y/N)	0	18	0%
Evidence of Dredging (Y/N)	1	18	6%

Table 9-13. Comparison of spring habitat quantitative results between sampling crews and QC Officer.						
Variable	**N***	**Mean Original Sample**	**Mean Duplicate Sample**	**Mean CV**	**Median RPD**	**Number of Sites with RPD > 20%**
Distance from road (m)	10	252	249	0.11	1.69	2
Aesthetic rating (1-20)	16	14.38	15.13	0.12	10.82	4
Width of riparian vegetation - left bank (m)	16	43.75	43.75	0	0	0
Width of riparian vegetation - right bank (m)	16	44.06	43.62	0.02	0	2
Extent of concrete left bank (m)	18	5.06	5.22	0.01	0	1
Extent of concrete bottom (m)	18	5.06	5.22	0.01	0	1
Extent of concrete right bank (m)	18	5.17	5.39	0.01	0	1
Extent of riprap on left bank (m)	18	2.22	2.06	0.003	0	0
Extent of riprap on bottom (m)	18	0	0	0	0	0
Extent of riprap on right bank (m)	18	0	0	0	0	0
Extent of berm left bank (m)	18	16.78	20.83	0.31	0	4
Extent of berm bottom (m)	18	12.5	16.67	0.24	0	3
Extent of berm right bank (m)	18	12.5	16.67	0.24	0	3
Extent of pipe (m)	18	0.33	0	0.08	0	1
Extent of dredge spoil (m)	18	4.17	0	0.08	0	1

9.6.2 Summer Index Period

Following the MBSS Sampling Manual protocols (Kazyak 2001) for the summer index period, several habitat characteristics (instream habitat, epifaunal substrate, velocity/depth diversity, pool/glide/eddy quality, and riffle/run quality) are assessed qualitatively on a 0-20 scale, based on visual observations within each segment and following standardized narrative descriptions. The percentage of embeddedness of the stream channel and the percentage of shading of the stream site are estimated. Also recorded are the extent and severity of bank erosion and bar formation, number of woody debris and rootwads within the stream channel, and the presence of various stream features such as substrate types, various morphological characteristics, and beaver ponds. Maximum depth within the segment is also measured. Wetted width, thalweg depth, and thalweg velocity are recorded at four transects.

The QC Officer made independent habitat assessments of 15 sites during the 2001 summer index period (7.5% of the 199 sites sampled). For the qualitative data, 11 variables were in disagreement at more than 20% of the sites (Table 9-14). This disagreement rate is down from the rate noted at the 13 sites in the MBSS 2000 sampling season. These variables were severity of bank erosion (left and right banks), gravel present in bar formation, relative abundance of exotic plants (Japanese stilt grass, thistle, and other exotics), presence of riffles, presence of deep pools, presence of substrate (boulders, bedrock, and gravel).

To assess whether differences could be attributed to the difficulty in standardizing how individuals differentiate between minimum, moderate, and severe categories, or present and extensive categories, we reanalyzed several variables by grouping the moderate and severe categories, and present and extensive categories. Grouping of these category levels tended to improve the agreement between the field crew and QC Officer. Only 4 (relative abundance of exotic plants Japanese stilt grass, thistle, and other exotics, and presence of deep pools) of the 11 variables that were originally in disagreement at greater than 20% of the sites remained above this threshold after grouping of the category levels. For example, severity of erosion on the right bank variable disagreed between the sampling crew and QC Officer at 47% of the sites; however after regrouping, only 2 (14%) of the sites were in disagreement (Tables 9-13 and 9-14).

As seen in Tables 9-14 through 9-19 apparent disagreements between the QC Officer and sampling crew most often represent a difference of only one category.

For the results of the extent of exotic plants, no variables had disagreement of results at more than 20% of the sites (Table 9-17). Japanese honeysuckle had disagreement of results at 20% of the sites, and 2 sites (13%) still have a discrepancy after combining the present and extensive categories.

Table 9-14. Comparison of summer qualitative results between sampling crews and QC Officer						
	Original Data			Grouped Data		
Variable	# Samples Different	Total # of Samples	% of Samples Different	# Samples Different	Total # of Samples	% of Samples Different
Severity of bank erosion - left (1,2,3)	8	15	53%	7	15	47%
Severity of bank erosion - right (1,2,3)	7	15	47%	6	15	40%
No bar formation	0	15	0%	NA	NA	NA
Minimum bar formation	3	15	20%	NA	NA	NA
Moderate bar formation	2	15	13%	NA	NA	NA
Extensive bar formation	0	15	0%	NA	NA	NA
Cobbles present in bar	2	15	13%	NA	NA	NA
Gravel present in bar	1	15	7%	NA	NA	NA
Sand present in bar	4	15	27%	NA	NA	NA
Silt/Clay present in bar	2	15	13%	NA	NA	NA
Relative abundance of multiflora rose (A,P,E)	0	15	0%	0	15	0%
Relative abundance of Mile-a-Minute (A,P,E)	0	15	0%	0	15	0%
Relative abundance of Japanese honeysuckle (A,P,E)	3	15	20%	2	15	13%
Relative abundance of Phragmites (A,P,E)	1	15	7%	1	15	7%
Relative abundance of Japanese stilt grass (A,P,E)	3	15	20%	3	15	20%
Relative abundance of thistle (A,P,E)	0	14	0%	0	14	0%
Relative abundance of other exotic	5	15	33%	5	15	33%
Type of other exotic	5	15	33%	5	15	33%
Stream braided (A,P,E)	4	15	27%	4	15	27%
Riffle (A,P,E)	1	15	7%	0	15	0%
Run/Glide (A,P,E)	5	15	33%	0	15	0%
Deep Pool (>=.5m) (A,P,E)	3	15	20%	2	15	13%
Shallow Pool (<.5m) (A,P,E)	5	15	33%	1	15	7%
Boulder >2m (A,P,E)	0	15	0%	0	15	0%
Boulder <2m (A,P,E)	1	15	7%	0	15	0%
Cobble (A,P,E)	4	15	27%	0	15	0%
Bedrock (A,P,E)	2	15	13%	1	15	7%
Gravel (A,P,E)	4	15	27%	2	15	13%
Sand (A,P,E)	5	15	33%	2	15	13%
Silt/Clay (A,P,E)	3	15	20%	0	15	0%
Undercut Bank (A,P,E)	3	15	20%	3	15	20%
Overhead Cover (A,P,E)	0	15	0%	0	15	0%
Beaver Pond (A,P,E)	1	15	7%	1	15	7%

*Moderate and severe, and present and extensive categories were grouped together.

1 = Minimum, 2 = Moderate, 3 = Severe

A = Absent, P = Present, E = Extensive

Table 9-15. Comparison of severity of erosion on left and right banks between the sampling crews and QC Officer

Left Bank

Sampling Crew (rows) / QC Officer (columns)

	None	Min	Mod	Sev
None	4			
Min	2		4	
Mod		1	3	
Sev			1	

Right Bank

Sampling Crew (rows) / QC Officer (columns)

	None	Min	Mod	Sev
None	4			
Min	1	1	4	
Mod		1	2	1
Sev				1

Min = minimum, Mod = moderate, Sev = Severe

Table 9-16. Comparison of extent of bar formation between the sampling crews and QC Officer

Sampling Crew (rows) / QC Officer (columns)

	None	Min	Mod	Ext
None	4			
Min	1	3		
Mod		2	2	
Sev				3

Min = minimum, Mod = minor, Ext = extensive

Table 9-17. Comparison of extent of exotic plants between the sampling crews and QC Officer

Multiflora Rose

Sampling Crew (rows) / QC Officer (columns)

	A	P	E
A	8		
P		6	
E			

Mile-a-Minute

Sampling Crew (rows) / QC Officer (columns)

	A	P	E
A	15		
P			
E			

Japanese Honeysuckle

Sampling Crew (rows) / QC Officer (columns)

	A	P	E
A	4		1
P	1	6	1
E			2

Phragmites

Sampling Crew (rows) / QC Officer (columns)

	A	P	E
A	14		
P	1		
E			

A=absent, P=present, E=extensive

Table 9-18. Comparison of stream character between the sampling crews and QC Officer

Braided

Sampling Crew \ QC Officer	A	P	E
A	11	3	
P	1		
E			

Riffle

Sampling Crew \ QC Officer	A	P	E
A	7		
P		6	
E		1	1

Run/Glide

Sampling Crew \ QC Officer	A	P	E
A	1		
P		3	5
E			6

Deep Pool (>=0.5m)

Sampling Crew \ QC Officer	A	P	E
A	4		
P	2	8	1
E			

Missing 1 QC result

Shallow Pool (<0.5m)

Sampling Crew \ QC Officer	A	P	E
A			
P		6	2
E	1	2	3

Boulder (>2m)

Sampling Crew \ QC Officer	A	P	E
A	11		
P	1	3	
E			

Boulder (<2m)

Sampling Crew \ QC Officer	A	P	E
A	10		
P		2	1
E			2

Cobble

Sampling Crew \ QC Officer	A	P	E
A	8		
P		2	1
E		3	1

Bedrock

Sampling Crew \ QC Officer	A	P	E
A	13	1	
P			1
E			

Gravel

Sampling Crew \ QC Officer	A	P	E
A	4		
P	2	2	
E		2	5

Sand

Sampling Crew \ QC Officer	A	P	E
A			
P	1	5	1
E	1	2	5

Silt/clay

Sampling Crew \ QC Officer	A	P	E
A			
P		9	3
E			3

Undercut Bank

Sampling Crew \ QC Officer	A	P	E
A	3	2	
P	1	9	
E			

Overhead Cover

Sampling Crew \ QC Officer	A	P	E
A	1		
P		13	
E			1

A=absent, P=present, E=extensive

Table 9-19. Comparison of summer habitat quantitative results between sampling crews and QC Officer.						
Variable	**N**	**Mean Original Sample**	**Mean Duplicate Sample**	**Mean CV**	**Median RPD**	**Number of Sites with RPD > 20%**
Extent of bank erosion - left bank (m)	15	25.60	18.33	0.43	60.87	10
Extent of bank erosion - right bank (m)	15	27.67	20.33	0.35	68.23	8
Erosion severity of left bank	15	1.13	1.13	0.36	66.67	8
Erosion severity of right bank	15	1.13	1.33	0.27	66.67	7
Eroded area of left bank (m2 x 10)	15	1.87	1.20	0.69	127.27	11
Eroded area of right bank (m2 x 10)	15	2.20	1.93	0.59	100.00	10
No. of instream woody debris	15	3.80	4.47	0.21	40.00	6
No. of dewatered woody debris	15	6.13	5.47	0.41	66.67	11
No. of instream rootwads	15	2.13	2.00	0.46	100.00	9
No. of dewatered rootwads	15	6.20	6.07	0.34	54.55	9
Instream habitat rating (1-20)	15	13.00	10.80	0.19	17.26	6
Epifaunal substrate rating (1-20)	15	12.20	9.47	0.22	22.22	7
Velocity/depth diversity rating (1-20)	15	10.60	10.60	0.13	10.53	4
Pool/glide/eddy quality rating (1-20)	15	11.33	11.67	0.14	18.18	6
Extent of Pool/glide/eddy (m)	15	51.20	54.47	0.16	27.27	7
Riffle/run quality rating (1-20)	15	9.07	9.60	0.16	22.22	4
Extent of riffle/run (m)	15	30.87	31.60	0.26	23.44	7
Embeddedness (%)	15	62.00	64.53	0.18	47.27	5
Shading (%)	15	82.00	80.07	0.08	7.49	1

Five of the fourteen variables for stream character (riffle, deep pool, boulder <2m, bedrock, and gravel) had discrepancies between results at greater than 20% of the sites. However, if the present and extensive categories are combined, there is only one variable (deep pool) that remains above 20% discrepancy (Table 9-18).

There were 19 quantitative variables measured or estimated during the summer index period (Table 9-19). Only two of these variables (instream habitat and epifaunal substrate) showed a statistically significant difference between the sampling crew scores and the QC Officer scores, suggesting good correspondence between the sampling crew and QC Officer's data for these variables. However, RPD scores for each variable indicate a poorer correspondence between sampling crews and QC Officer. RPD scores for all but three variables (velocity/depth diversity, pool/glide/eddy quality, and shaded area) were over 20%. This is because RPD's for each variable are determined for each site, then averaged to create one RPD per variable. In this case, one or two stations that had high RPD percentages can affect the rest. For example, of the 15 stations where embeddedness was measured, five had RPD values of over 20% (ranging from 40% to 97%). However there were seven stations that had RPD scores of 0%. The final average RPD of all the stations was 25.35%.

9.6.3 Temperature Loggers

During the 2001 MBSS, automated temperature loggers were placed at 206 of the randomly selected sites. Prior to field sampling, the calibration of all temperature loggers was verified by placing them into a bucket of water of a known temperature; no significant deviations were recorded. Loggers were deployed during spring sampling. Field crews made the best attempt possible to position the loggers in areas where they would stay under water and out of direct sunlight. The temperature loggers were set to begin recording on June 1 and to record the water temperature every 20 minutes until they were removed (generally in early September).

Of the 206 sites where temperature loggers were initially placed, the loggers were lost at 21 (10%) of those sites. Because the loggers were placed in the spring, during the period of high water, many of the streams dried up at some point during the summer, leaving the temperature logger recording air temperature. Data were screened for outliers (temperatures greater than 30 ˚C) and Field Crew Leaders were consulted for information concerning the condition of the streams where these high temperatures were being recorded. Because of the uncertainty at these stations about whether a high temperature was due to an actual increase in water temperature or because the stream had dried up, questionable data for the temperature loggers were not used in subsequent analyses. This included sites where the temperature logger was dry when checked by crews during summer sampling or when the temperature logger was retrieved in August. This uncertainty occurred at 9 of the 185 (5%) of the sites where temperature data could be retrieved. Uncertain data were excluded from subsequent data analyses.

10 REPORTING

Versar is responsible for writing and producing the MBSS annual report that analyzes and summarizes the data from each sampling year. Versar has developed detailed QA/QC procedures for document production to ensure that technical reports are of the highest quality and meet DNR's specific needs. Versar's report production procedure involves internal reviews by senior scientists who were not major authors, copy-editing, routine electronic spelling checks, and review of copies for production flaws before delivery to the client. For MBSS reports, the MBSS QC Officer also reviews all text and graphics prior to completion of the draft report. In addition to internal technical review, all major deliverables (draft and final versions) are copy-edited by a trained technical editor to ensure completeness, accuracy, consistency, and conformity to accepted style conventions (e.g., Government Printing Office Style Manual, Council of Biology Editors Style Manual, Chicago Manual of Style) and DNRs' specifications for format and usage. The QA/QC procedure helps ensure that all comments on drafts are addressed before delivery of the final. MBSS reports are also peer reviewed by DNR and three independent reviewers prior to final publication.

11 QA/QC RECOMMENDATIONS AND CONCLUSIONS

11.1 RECOMMENDATIONS

Overall, the results of our analysis of the QA data for the 2001 MBSS indicate that the rigorous training and adherence to the MBSS Sampling Manual (Kazyak 2000) is providing excellent data that can be used with confidence. We recommend the continuation of the rigorous training and adherence to all established QA/QC procedures in future years.

Additional specific recommendations to consider for incorporation into future MBSS protocols are as follows:

- Continue this QA Report as a means for external evaluation of MBSS data quality;
- Standardize the recording of observations made during field audits. Consider using a standardized QC checklist to facilitate quantitative reporting;
- Standardize the documentation of the numerous QC checks performed throughout data management and analysis. Consider using a standardized QC checklist to provide a detailed summary of specific QC actions;
- Develop MBSS-specific SOP's for all phases of the MBSS, including the analytical laboratory;
- Improve recordkeeping to identify sites where crew was in doubt about actual location;
- Develop a genus-level taxonomic key for benthos in Maryland to promote increased use of reference material and consistent naming;
- Provide a separate QC check of macroinvertebrate identification to supplement current evaluations of variability in field sampling and laboratory subsampling;
- Document questionable benthic taxonomic identifications (and their verification) and include in future QA reports;
- Revise fish key to account for new species (e.g., Blue Ridge sculpin) and problem identifications encountered by MBSS crews;
- Add a field audit of fish identification;
- Review qualitative physical habitat sampling variables (e.g., what is minimum, moderate or severe), provide additional training, and where appropriate group data into fewer categories for data analysis (e.g., group present and extensive);
- Improve methods to address habitat variables with the greatest discrepancies in order to increase precision;
- Improve technique used to measure bank erosion and bar formation in future rounds of the MBSS. This could include the use of digital photographs taken at the site to resolve any discrepancies;
- Continue to improve installation of temperature loggers to achieve better success in measuring water temperatures.
- Establish Data Quality Objectives (DQOs) for MBSS data;
- Collect information concerning the resolution of site locations in the field; and
- Collect information concerning unmapped tributaries within sample segments.

11.2 CONCLUSIONS

At the conclusion of the 2000 and 2001 sampling seasons, the MBSS has begun to compile a summary of median percent RPD for several parameters for each year (Table 11-1).

This table will allow the Survey to examine the consistency of the data from year to year and is the beginning of the establishment of benchmarks that the Survey should try to achieve for each parameter.

Table 11-1. Summary of MBSS 2000 and 2001 Median RPD scores for various Survey parameters					
Water Quality Laboratory Duplicates	**Median RPD**		**Water Quality Field Duplicates**	**Median RPD**	
	2000	**2001**		**2000**	**2001**
Closed pH	0.01	0.007	Closed pH	0.58	0.56
ANC	1.01	0.9	ANC	0.58	0.39
Conductance	0.68	0.45	Conductance	0.79	0.19
Chloride	0.62	0.51	Chloride	0.27	0.81
Nitrate-Nitrogen	0.86	1.14	Nitrate-Nitrogen	0.74	0.72
Sulfate	0.68	0.61	Sulfate	0.44	0.81
Nitrite-Nitrogen	0.0004	0.0001	Nitrite-Nitrogen	0	11.32
Ortho-Phosphate	0.001	0.0003	Ortho-Phosphate	16.13	38.44
Ammonia	0.003	0.003	Ammonia	3.64	8
TDN	1.74	2.67	TDN	11.22	2.58
TDP	2.95	4.04	TDP	11.76	5.61
DOC	3.3	4.2	DOC	5.03	3.83
PP	1.93	Not Sampled	PP	20.8	
PN	3.76	Not Sampled	PN	25.61	
Benthic IBI					
Benthic IBI - Field Duplicates	15.79	14.21			
Benthic IBI - Lab Duplicates	5.83	12.5			
Spring Habitat Variables					
Distance from Road	11.57	1.69			
Aesthetic Rating	5.89	10.82			
Altitude	0.59	Not Sampled			
Summer Habitat Variables					
Extent of left bank erosion	40	60.87	Epifaunal substrate rating	8.7	22.22
Extent of right bank erosion	37.53	68.23	Velocity/Depth diversity	10.53	10.53
Eroded area of left bank	46.32	66.67	Pool/glide/eddy quality rating	8.7	18.18
Eroded area of right bank	58.82	66.67	Extent of pool/gilde/eddy	14.14	27.27
No of instream woody debris	50	40	Riffle Run quality rating	20.63	22.22
No. of dewatered woody debris	59.65	66.67	Extent of riffle/run	37.84	23.44
No. of instream rootwads	66.67	100	Embeddedness	47.62	47.27
No. of dewatered rootwads	43.17	54.55	Shading	9.79	7.49
Instream Habitat rating	11.76	17.26			

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APPENDIX A

MBSS 2001 QC Notes

QC NOTE 1

SITE	COMMENTS
NEAS-201-R-2001	None
NEAS-202-R-2001	4 anodes called for during summer but stream is only 5-6 meters wide (TP confirmed depth and complexity of site requires 4 anodes)
NEAS-103-R-2001	Big 1st order– shows as 2nd order on ADC map; 4 anodes called for during summer but stream is 6-8 meters wide (TP confirmed depth and complexity of site requires 4 anodes)
NEAS-107-R-2001	4 anodes called for during summer but stream is 5-6 meters wide (TP confirmed depth and complexity of site requires 4 anodes)
NEAS-109-R-2001	Big 1st order– shows as 2nd order on ADC map
NEAS-111-R-2001	Deep- 9 ft anodes may be necessary
NEAS-312-R-2001	None
NEAS-115-R-2001	Only 52 meters with water- will probably be dry by summer
FURN-118-R-2001	Farm dump approximately 10 meters from bank
FURN-119-R-2001	None
LIGU-201-R-2001	Braided, 2 equal channels; **QC SAMPLES TAKEN**;
LIGU-102-R-2001	None
LIGU-102-R-2001	Cow pasture, difficult to flag
LIGU-104-R-2001	Will probably be dry in summer
LIGU-105-R-2001	None
LIGU-306-R-2001	Almost same reach as LIGU-312
LIGU-312-R-2001	Almost same reach as LIGU-306
LIGU-109-R-2001	Abundant multiflora rose
LIGU-110-R-2001	None
LIGU-111-R-2001	Lots of silt from upstream development
BODK-101-R-2001	None
BALT-202-R-2001	Oil leaking slowly into stream from fuel company property; forgot to label page number on 2nd page
BALT-103-R-2001	Site is almost totally under I-695 and is a box culvert with standing water; based on size of stream channel, this stream becomes a raging torrent during storms; no temp logger deployed because stream will be dry by late spring (basically dry now)
BALT-104-R-2001	Sewer line parallel to stream
BALT-105-R-2001	Stream is gone- may be piped underground
BALT-106-R-2001	Concrete channel and may be dry in summer; large rat observed
BALT-207-R-2001	Upper 28 meters is in culvert but is sampleable; will need headlamps to do this site (may want to block off culvert entrance with extra nets to minimize number of fish in dark culvert); **QC SAMPLES TAKEN**; in CHANNELIZATION section bottom is not listed as being concrete– should it be?
BALT-108-R-2001	Tons of trash at site; gabion sides and bottom
BALT-109-R-2001	Dry streambed
BALT-110-R-2001	None
BALT-111-R-2001	Dry streambed
BALT-112-R-2001	Dry concrete channel
BALT-113-R-2001	2 separate channels
BALT-214-R-2001	Part of beaver pool- may need long anodes
DEER-101-R-2001	Big 1st order; air temp logger installed at this site along with instream logger
DEER-103-R-2001	Abundant multiflora rose
DEER-105-R-2001	None
DEER-106-R-2001	Stream is in pasture; QC SAMPLES TAKEN
DEER-109-R-2001	None
DEER-110-R-2001	None

DEER-112-R-2001	Abundant multiflora rose
DEER-113-R-2001	None
DEER-117-R-2001	Site moved 37 meters because of inpenetrable multiflora rose jungle; part of pasture
DEER-207-R-2001	None
DEER-302-R-2001	Seems big for 3rd order stream- 8 anode site
DEER-404-R-2001	8 anode site
DEER-408-R-2001	12 anode site
DEER-414-R-2001	9 anode site
PRUT-103-R-2001	None
PRUT-106-R-2001	None
PRUT-107-R-2001	Mud bottom, lots of trash
PRUT-108-R-2001	Iron bacteria floc on stream bottom
PRUT-114-R-2001	None
PRUT-117-R-2001	None
PRUT-202-R-2001	Channelized, with concrete channel just upstream
PISC-103-R-2001	Mega bar formation
PISC-104-R-2001	None
PISC-105-R-2001	**Raw sewage evident**
PISC-106-R-2001	Extreme bank erosion; lots of old trash
PISC-109-R-2001	Mega silt deposition
PISC-112-R-2001	Major deposition of sand and gravel
PISC-113-R-2001	**QC SAMPLES TAKEN**
PISC-115-R-2001	Orange rock and lots of silt
PISC-201-R-2001	Severe bank erosion and gravel deposition; development upstream
PISC-207-R-2001	None
OXON-101-R-2001	Sewage smell; direct parking lot drainage
OXON-205-R-2001	Sewage smell; concrete channel; no fish
ZEKI-103-R-2001	**QC SAMPLES TAKEN**; mega briars
ZEKI-104-R-2001	Recent logging adjacent to site- selective harvest; same reach as ZEKI-012-S-2001
ZEKI-106-R-2001	Heavy, recent logging along stream; lots of sand and gravel deposition and eroding bank
ZEKI-109-R-2001	Same stream as 114
ZEKI-114-R-2001	Same stream as 109; heavy bar formation, down-cutting and bank erosion
ZEKI-116-R-2001	6 meters of site is in culvert
ZEKI-117-R-2001	At confluence with Zekiah Swamp- may be dry in summer
ZEKI-118-R-2001	Braided- little defined channel; requires many block nets
ZEKI-215-R-2001	Significant deposition; stream has much better looking habitat and is more sinuous 500 meters upstream in wooded wetland
ZEKI-302-R-2001	Beaver pond and lodge within site but still wadable; 1 braid is channelized (noted during field QC audit); 12 anode site
ZEKI-305-R-2001	8 anode site; braided and deep
ZEKI-307-R-2001	8-10 anode site
ZEKI-312-R-2001	12 anode site; braided; straight line distance is 75 meters but all braids are sinuous- SHOULD FOLLOW BIGGEST BRAID WHEN LAYING OUT SEGMENT- REMEASURE AND MARK SITE IN SUMMER
GILB-101-R-2001	Selective logging within riparian zone and mega algae in stream
GILB-108-R-2001	Small trib within segment
GILB-109-R-2001	Cows have access to upstream 25 meters of segment; **QC SAMPLES TAKEN**; same stream as GILB-114
GILB-111-R-2001	Mega briars
GILB-112-R-2001	Lots of sand, deposition, erosion; **CHANNELIZATION SECTION NOT FILLED IN**

GILB-114-R-2001	Cows have access to stream- very silty stream; on same stream as GILB-109
GILB-115-R-2001	Beaver pond- tough to find good benthic habitat
GILB-213-R-2001	Mega green briar; mud and leaf bottom- maybe flow impaired since 2nd order stream?
GILB-307-R-2001	None
GILB-306-R-2001	None
PAXM-119-R-2001	Mega trash and rotting deer carcass
NANT-311-R-2001	Stream impounded 500m downstream and is tidal below dam;
NANT-107-R-2001	NANT-114 about 700 m downstream
NANT-110-R-2001	Stream is mostly algae and garbage substrate; park of community park
NANT-114-R-2001	Impoundment downstream; wide swamp with many channels but likely will shrink
NANT-113-R-2001	None
NANT-116-R-2001	None
NANT-203-R-2001	None
NANT-102-R-2001	Small stream- leaf substrate; this type of stream is often dry in summer- may want to consider as flow impaired if watershed is bigger than 300 acres
NANT-108-R-2001	Small stream- leaf substrate; this type of stream is often dry in summer- may want to consider as flow impaired if watershed is bigger than 300 acres
NANT-119-R-2001	Map was wrong or stream was moved- coords 110 meters from stream
CHIN-103-R-2001	Pond 150 meters below site; stream flows through cornfields; based on site description, buffer break should be crop and not pasture
CHIN-112-R-2001	CHIN-103 is 500 meters downstream; substrate is leaves and needles
CHIN-119-R-2001	None
NEWP-110-R-2001	No defined channel
NEWP-116-R-2001	Pond outlet may affect stream temp
DIVI-109-R-2001	Substrate is deep mud; DIVI-112 is approx 500 meters downstream
DIVI-111-R-2001	None
DIVI-112-R-2001	DIVI-109 is approx 500 meters downstream
DIVI-218-R-2001	Swampy, soft bottom
DIVI-110-R-2001	**No logger put in– unclear why**
DIVI-104-R-2001	None
DIVI-119-R-2001	Pine needle substrate; this type of stream is often dry in summer- may want to consider as flow impaired if watershed is bigger than 300 acres
DIVI-107-R-2001	Wide swamp; braids
NASS-206-R-2001	Approx 75 meters wide during spring visit- difficult to determine sampling effort for summer; straight line distance measured over 87 meters because of culvert
NASS-217-R-2001	3 braids
UPPC-106-R-2001	None
UPPC-204-R-2001	Deep, very soft bottom
UPPC-216-R-2001	Muddy ditch
UPPC-103-R-2001	Mud bottom, flows between corn fields; same stream as UPPC-118
UPPC-410-R-2001	Mud/sand bottom and deep
UPPC-113-R-2001	**TWO SETS OF DATA SHEETS FOR THIS SITE-- ONE SAMPLED LATER SHOULD BE UPPC-105 SINCE THAT SITE IS APPROX 500m UPSTREAM. SAMPLING TIMES WERE 1000 AND 1100. QC OFFICER PRESENT FOR THESE SITES- USED QC DATA SHEETS TO VERIFY SITES AND MADE CHANGE TO SITE SAMPLED AT 1100– STILL NEED TO CHECK WATER CHEMISTRY SAMPLES FOR SAME PROBLEM.....**

NEW **UPPC-105-R-2001**	**CHANGED SITE NAME FROM UPPC-113**
UPPC-101-R-2001	Leaf/needle substrate- flow impaired?
UPPC-117-R-2001	Pond approx 10 meters downstream; landfill nearby; probably dry in summer; **Adjacent land cover 13 meters from left bank listed as LO (logged area), but comments describe a pond on left bank 13 meters away**
UPPC-118-R-2001	Same stream as UPPC-103; muddy with lots of algae
UPPC-107-R-2001	Same stream as UPPC-114
UPPC-114-R-2001	Same stream as UPPC-107
UPPC-115-R-2001	**Is pasture reason that no logger was deployed? Unclear**
ISLE-115-R-2001	Site liked by crew leader- optimal habitat
ISLE-120-R-2001	None
ISLE-105-R-2001	Same stream as ISLE-120 and ISLE-107; using same logger; **CHANGED CHANNELIZATION- BOTTOM WAS LISTED AS DREDGE SPOIL OFF CHANNEL AND SHOULD HAVE BEEN EARTH**
ISLE-107-R-2001	Using temp logger from ISLE-120; **CHANGED CHANNELIZATION- BOTTOM WAS LISTED AS DREDGE SPOIL OFF CHANNEL AND SHOULD HAVE BEEN EARTH** (QC NOTE: modify data sheet next year so that Dredge spoil on stream bottom is not an option)
SENE-113-R-2001	Failed to sign for verification of benthic sample labels
SENE-119-R-2001	Dry by summer; 0 buffer (cropland), but Grass and Regen listed as vegetation types
SENE-306-R-2001	None
SENE-115-R-2001	Probably dry in summer; migration barrier just downstream
SENE-114-R-2001	QC samples collected; 4 whitetail deer carcasses in stream and on back
SENE-103-R-2001	Culvert in segment **(is gradient over longer distance?)**
SENE-316-R-2001	**Part of site is in huge arch culvert but distance from road is 420 meters?**
SENE-101-R-2001	None
SENE-205-R-2001	None
SENE-109-R-2001	None
SENE-104-R-2001	None
SENE-117-R-2001	35 meters from Seneca Creek confluence
SENE-210-R-2001	Fresh beaver sign; site SENE-211 is 1 km upstream
SENE-211-R-2001	SENE-210 is about 1km downstream; beaver pond is 600 m upstream; substrates are black
SENE-112-R-2001	Almost no flow
SASS-102-R-2001	15 sites visited in this PSU- 5 dry; 1 in pond
SASS-120-R-2001	Site includes small beaver pond- deep areas present
SASS-104-R-2001	Huge beaver pond ~70 m upstream from site
SASS-205-R-2001	Stream looks good but benthos not very good
STILL-103-R-2001	Clearing of multiflora rose required to sample
STILL-106-R-2001	Streambed large but dry
STILL-207-R-2001	Landfill across street but drains to stream below site
STILL-108-R-2001	Site in middle of pond- not sampleable
STILL-109-R-2001	QC samples collected; may have been beaver pond at one point
STILL-110-R-2001	No stream at site coordinates
STILL-111-R-2001	Dry stream
STILL-112-R-2001	Dry stream- site is just upstream from STIL-106
STILL-113-R-2001	Dry stream; **sample label verifications signed for by crew leader- how were samples collected from dry stream?**
STILL-114-R-2001	Site is just upstream from Fairlee Lake
STILL-119-R-2001	Beaver activity present within site
PAXM-121-R-2001	Site moved 75 m upstream to be above head of tide

PAXM-107-R-2001	Severe bank erosion and downcutting; **QC site**
PAXM-109-R-2001	Trib enters within segment
PAXM-115-R-2001	Severe erosion; trib enters within segment
PAXM-101-R-2001	**Writing could be neater**
PAXM-106-R-2001	Gravelly stream; least brook lamprey observed spawning; nice stream
PAXM-211-R-2001	Extensive bar development
PAXM-112-R-2001	Clay bottom with a little gravel/cobble; horse pasture upstream
PAXM-213-R-2001	GPS went complete on a very small stream 100 m from Cabin Branch–segment located on mainstem instead
PAXM-122-R-2001	Sand/gravel substrate
PAXM-114-R-2001	Segment moved 100 m upstream because of permission problem
PAXM-120-R-2001	**Data sheets smeared in some places- difficult to photocopy**
WEBR-106-R-2001	Segment moved upstream because of 75 m long unsampleable culvert; **QC site**
WEBR-107-R-2001	70 m of segment is in beaver pond; landowners want info. sent to them
WEBR-105-R-2001	Landowners want info. sent to them
WEBR-111-R-2001	Site is ~150 m upstream from WEBR-105
WEBR-113-R-2001	Stream impounded 200 m downstream; substrate is orange
WEBR-110-R-2001	Just upstream from PG Cty site 40-TO1 sampled on 3/20/01; pipe dumping orange water into segment
WEBR-212-R-2001	Doesn't look too bad considering highly urban land use
WEBR-201-R-2001	Clay bottom; trib enters within segment
WEBR-116-R-2001	Half of site is straight and channelized; half is braided and swampy
WEBR-104-R-2001	Large beaver impoundment that is more like wetland than a stream- will be difficult to sample in summer
YOUG-101-R-2001	Probably acidic due to geology
YOUG-208-R-2001	Sentinel site about 2 miles downstream
YOUG-110-R-2001	Midpoint of segment 10 m below road, but no permission above road so segment moved to be entirely below road; **for calculation purposes, culvert should be included in data as being present in segment (include in channelization too?)**
YOUG-117-R-2001	Sampled ~50 m downstream in 1999; Mill Run is reference watershed
YOUG-221-R-2001	Habitat improvements done by ACOE, but habitat was already optimal; Youghiogheny Lake ~200 m downstream; **QC site**
YOUG-123-R-2001	YOUG-117 is on opposite fork
PRUN-103-R-2001	None
PRUN-107-R-2001	PRUN-103 is ~250 m downstream
PRUN-106-R-2001	AMD impacted
SIDE-101-R-2001	Freshly deceased calf on bank; very small stream- likely to be dry in summer
SIDE-402-R-2001	None
SIDE-109-R-2001	None
SIDE-410-R-2001	Active beaver dam 100 m below segment
SIDE-405-R-2001	None
PRAL-103-R-2001	Stream predicted to be dry soon
PRAL-104-R-2001	None
PRAL-106-R-2001	PRAL-208 is 2 km downstream; probably dry by summer
PRAL-107-R-2001	None
PRAL-208-R-2001	PRAL-106 is upstream; **QC site**

QC NOTE 2

SITE	**COMMENTS**

PRUN-211-R-2001	Sampled same reach (GA-A-222-96) in 1996; new lime doser has since been installed; excellent habitat
PRUN-205-R-2001	None
PRUN-210-R-2001	Lime doser upstream; had coldwater site on this stream in 2000; 3 random sites in 1996; PRUN-205 is ~750 m downstream
PRUN-104-R-2001	None
PRUN-101-R-2001	Segment at site of former beaver dam; fresh dam and sign below segment
PRUN-102-R-2001	Segment at site of old beaver dam
PRUN-109-R-2001	Segment at site of old beaver dam; gravel road crosses within segment; active beaver dam ~200 m downstream; **straight line distance measured over 81 m because of culvert**
YOUG-214-R-2001	None
YOUG-219-R-2001	None
YOUG-102-R-2001	None
YOUG-107-R-2001	Old fences suggest that riparian area was historically pasture; forested now
YOUG-118-R-2001	Beaver dams below, above, and within segment
YOUG-127-R-2001	YOUG-106 is ~ 700 m upstream
YOUG-106-R-2001	YOUG-127 is ~ 700 m downstream; recent logging (clear cuts) about 250 m upstream- can use these two sites to look at above/below clearcut for possible impact
YOUG-320-R-2001	Sampled this reach 3 times in 1997; fresh beaver sign
YOUG-231-R-2001	Probably acidified- segment is ~100 m above Herrington confluence - Murley Run sampled extensively in 1995 and monitored since as well by AL
YOUG-112-R-2001	Cow pasture ~150 m upstream; very thick rhododenron so gradient only measured over bottom 35 m of site and straight line estimated

QC NOTE 3

No Random Sites

QC NOTE 4

<u>**SITE**</u>	<u>**COMMENTS**</u>
BALT-202-R-2001	Sawmill Creek site with strong petroleum smell and leakage to stream (but more spp than expected)
DEER-103-R-2001	
DEER-105-R-2001	
DEER-106-R-2001	
DEER-109-R-2001	Fish abundance lower than expected; lots of sed transport (sand)
DEER-110-R-2001	High gradient, low diversity and abundance
DEER-112-R-2001	Mega multiflora rose site
DEER-113-R-2001	
DEER-117-R-2001	

QC NOTE 5

<u>**SITE**</u>	<u>**COMMENTS**</u>
ISLE-105-R-2001	
ISLE-120-R-2001	Site 105 ~300m upstream; Logging in progress
ISLE-107-R-2001	Mud ditch
ISLE-115-R-2001	
CHIN-119-R-2001	QC visit site

CHIN-103-R-2001	Lower 50 meters wadable part of a farm pond inlet; near zero flow; recently dredged (ie., between spring and summer visit)
CHIN-112-R-2001	Dry; CHIN-1-3 is ~1km downstream; if a snake cannot be positively identified, record as snake sp.
DIVI-119-R-2001	Ditch with no flow
NANT-203-R-2001	QC visit site
NANT-116-R-2001	
NANT-102-R-2001	Ditch with very little flow
NANT-108-R-2001	
NANT-119-R-2001	
UPPC-107-R-2001	**A copy of these data sheets was also submitted**
UPPC-114-R-2001	Emergent veg extensive throughout segment; **avoid erasures/writeovers– simply line out and write correct entry above or to the side; use complete common names for fish species**
UPPC-103-R-2001	Mega silt site
UPPC-106-R-2001	Very little flow, mostly shallow with little cover
UPPC-117-R-2001	No flow- 30 meters of shallow standing water
UPPC-101-R-2001	Dry, even with significant rainfall previous week and early in summer; **don't cross out herp section of data sheet if search was made and none found**
DIVI-112-R-2001	
DIVI-110-R-2001	Ditch with abundant frog populations
YOUG-106-R-2001	YOUG-127 is ~500m downstream
YOUG-127-R-2001	Nice stream; watershed nearly all state land; new logging operations evident
NEWP- 116-R-2001	Effluent from capped landfill about 10m above segment; nicest Ocean Coastal stream sampled; fish dominated by eels
ZEKI-117-R-2001	Partly channelized
ZEKI-103-R-2001	Small stream; mega greenbriar
ZEKI-104-R-2001	Right bank of stream recently selectively logged
GILB-306-R-2001	Clay bottom; fast water
GILB-307-R-2001	Channelized and fast
GILB-112-R-2001	Shallow and probably goes dry in late summer; QC site
GILB-111-R-2001	
GILB-101-R-2001	Recent selective logging along stream; deep pools with shallow riffles
GILB-109-R-2001	Part of segment in pasture
GILB-108-R-2001	Some lampreys too small to net; nice stream- not much downcutting
GILB-114-R-2001	Part of segment in pasture
WEBR-106-R-2001	Poor habitat and low DO and just above an impoundment
WEBR-116-R-2001	Silt bottom and partly ditched; **check photo of mud turtle for confirmation (may be musk)**
WEBR-113-R-2001	Heavy silt and above and impoundment; 1/3 channelized
PAXM-211-R-2001	Good fish habitat
PAXM-107-R-2001	Heavy silt and extensive erosion]
PAXM-122-R-2001	Small; probably goes dry in late summer
PAXM-106-R-2001	
LIGU-103-R-2001	Cows in stream on DNR land
LIGU-104-R-2001	Very little water and no fish
LIGU-105-R-2001	
LIGU-102-R-2001	Brook trout present
LIGU-109-R-2001	Lots of multiflora rose; stream runs through cow pasture and is silty but 1 brook trout present
LIGU-110-R-2001	
LIGU-111-R-2001	Very silty

LIGU-201-R-2001	**Bucket spilled at end of second pass- additional effort recovered most fish**
DEER-101-R-2001	Wide, shallow stream
DEER-207-R-2001	Lots of YOY brown trout
NEAS-103-R-2001	Appears large for a 1st odrer stream
NEAS-107-R-2001	QC site; historically channelized, mostly slow and deep with a beaver dam influencing lower 50m of segment; pulled part of dam for second pass– visibility same or better even though slow moving and silt bottom
NEAS-109-R-2001	Beaver impoundment present; big for 1st order– 2nd order based on ADC map
NEAS-115-R-2001	Dry
NEAS-201-R-2001	QC site; bucket spilled after 1st pass- nearly complete recovery but 1 green sunfish known to be lost
NEAS-202-R-2001	
FURN-119-R-2001	Very low flow; poor visibility on 2nd pass
BALT-103-R-2001	70 meters of site in concrete culvert under I-695 on-ramp; low DO and no flow (or fish)
BALT-104-R-2001	Low DO and no fish
BALT-106-R-2001	Concrete channel and highly flashy; no fish
BALT-108-R-2001	"Nasty" stream
BALT-110-R-2001	Silt/clay abundant
BALT-113-R-2001	Braided channel; dewatered in some areas
BODK-101-R-2001	

QC NOTE 6

SITE	COMMENTS
BALT-202-R-2001	Sawmill Creek site with strong petroleum smell and leakage to stream (but more spp than expected)
DEER-103-R-2001	
DEER-105-R-2001	
DEER-106-R-2001	
DEER-109-R-2001	Fish abundance lower than expected; lots of sed transport (sand)
DEER-110-R-2001	High gradient, low diversity and abundance
DEER-112-R-2001	Mega multiflora rose site
DEER-113-R-2001	
DEER-117-R-2001	
SASS-102-R-2001	Poor sampling efficiency because of excess aquatic vegetation; DO = 1.6 ppm
SASS-205-R-2001	Nice coastal plain stream
SASS-104-R-2001	Very nice coastal plain stream
STILL-103-R-2001	Small stream; low flow
STILL-207-R-2001	Good herp site
STILL-109-R-2001	Excessive aquatic vegetation– sampling difficult
STILL-114-R-2001	Small stream with very little flow; just upstream of Fairlee Lake and loaded with YOY bullhead
LIGU-306-R-2001	
LIGU-312-R-2001	Site 306 ~150 meters downstream
DEER-414-R-2001	>40 kg fish biomass– new MBSS record
DEER-302-R-2001	Barge shocker used
DEER-408-R-2001	
DEER-404-R-2001	
SENE-103-R-2001	
SENE-101-R-2001	
SENE-109-R-2001	
SENE-114-R-2001	
SENE-115-R-2001	Very small stream
SENE-113-R-2001	
SENE-104-R-2001	Heavy silt in slow areas
SENE-117-R-2001	
SENE-112-R-2001	1 fish; almost no flow but max depth = 0.4 m– fish should have been more abundant
YOUG-127-R-2001 (page 4 of 5)	
YOUG-101-R-2001	No fish; very little flow
YOUG-231-R-2001	3 fish collected in Murley Run even though pH= 5.3
SIDE-109-R-2001	Very small and low flow; no fish
SIDE-101-R-2001	
PRAL-208-R-2001	Low flow, probably dry by end of summer
PRAL-106-R-2001	Dry stream
PRAL-104-R-2001	Dry stream
PRAL-107-R-2001	Little water in most of segment- 2 big pools **Conflict on data sheets for length of segment actually sampled comments on page 4 say 70 meters, but page 2 lists 75m**
PRUN-205-R-2001	**No need to identify which gamefish are from 2nd pass**
PRUN-210-R-2001	Site 205 is ~1km downstream
PRUN-101-R-2001	**pH value hard to read– line out and write correct value directly above**

PRUN-211-R-2001	Sampled this stream in '96; lime doser installed since then but still no fish; substrates concreted
PISC-201-R-2001	
PISC-207-R-2001	**"Black rat" listed as herp spp– use full common name**
PISC-109-R-2001	sewage odor strong
PISC-103-R-2001	Rootwad and assoc. debris dam reduced electrofishing efficiency
PISC-113-R-2001	
PISC-112-R-2001	Piedmont-like stream
PISC-115-R-2001	Very soft mud (1-2 inches thick) covering sand/gravel
PISC-104-R-2001	High bank erosion evident
PISC-106-R-2001	Downcutting and garbage in abundance
PAXM-121-R-2001	Nice wetland stream in Jug Bay sanctuary
PAXM-112-R-2001	Site turbid but shallow and visible; yellow grub in American eel
PRUT-202-R-2001	pH probe not functioning (back up bad too)-- **is pH value from a different day or a bad reading?**; channelized with boulders placed in stream
PRUT-108-R-2001	pH taken next day due to equip problem
PRUT-103-R-2001	Riparian veg nearly inpenetrable
PRUT-107-R-2001	Iron bacterial floc covered entire stream bottom; no fish
PRUT-114-R-2001	Concrete channel just above site; small with notable silt deposition
PRUT-117-R-2001	Beaver dam upstream; shallow and swampy; DO=2.3; very low flow
PRUT-116-R-2001	Piedmont-looking stream; no fish; culvert migration barrier about 100 m downstream
ZEKI-109-R-2001	
ZEKI-114-R-2001	Large pond ~ 100m downstream
ZEKI-106-R-2001	Recent logging
ZEKI-116-R-2001	Shallow, blackwater stream
ZEKI-215-R-2001	Mostly clay bottom

OXON-205-R-2001	Norway rats observed; no fish; replacement logger installed; cement channel with some gravel/cobble on bottom
OXON-101-R-2001	Good habitat but almost no fish

QC NOTE 7

SITE	**COMMENTS**
NEAS-111-R-2001	Temp logger found dewatered- redeployed in water at 1300
STIL-119-R-2001	No flow but turbid (beaver activity noted- may be cause)
FURN-118-R-2001	
BALT-207-R-2001	Low flow but turbid (beaver activity noted- may be cause)
BALT-214-R-2001	Low flow but turbid (beaver activity noted- may be cause)
WEBR-107-R-2001	Low flow but turbid (beaver activity noted- may be cause) ; **writing too light in some places on habitat sheet**
WEBR-111-R-2001	Oyster-like fossils present at site; COMPARE DISCHARGE WITH WEBR-105
WEBR-105-R-2001	**Lamprey spp. need identified prior to data entry (all data sheets with pending id's should be held until confirmed- and confirmation should be expedited)**
WEBR-201-R-2001	Heavy deposits of fine material; mostly a clay bottom
WEBR-110-R-2001	Extensive erosion; hard clay bottom
PAXM-115-R-2001	Severe erosion!
PAXM-213-R-2001	Temp logger found dewatered– relocated to deeper water; site difficult to sample because of deep hole/ undercut with rootwad; highly eroded banks and hard clay bottom
PAXM-119-R-2001	Very small stream; garbage a significant part of habitat structure
PAXM-109-R-2001	Sand bottom with fossils in segment
PAXM-101-R-2001	Loose, shifty substrate
PISC-105-R-2001	Crew noted severe sewage smell– man-hole access next to stream (conductivity low– direct input to stream probably not occurring en masse); iron bacterial floc covered substrate **(should be considered in embeddedness score as per guidance sheet)**
MATT-033-R-2001	No flow; logger found dewatered– redeployed

QC NOTE 8

SITE	**COMMENTS**
NEAS-312-R-2001	
SASS-120-R-2001	
YOUG-123-R-2001	
YOUG-117-R-2001	
YOUG-221-R-2001	SMB likely coming upstream from Youghiogheny Reservoir; **writing on Fish Data Sheet should be less script-like**
YOUG-208-R-2001	
YOUG-320-R-2001	Stream drains Cranesville Swamp- lots of wetlands upstream; **Pool/Glide/Eddy score written over and hard to read (appears to be a 15 or 16- I wrote 16 as best guess)**
NANT-107-R-2001	
NANT-110-R-2001	Only 1 pass completed– substrate + water depth too deep to sample; small percentage of fish seen were actually netted because of thick aquatic vegetation. **Do not use for IBI calculations- safer to call site unsampleable for fish**
UPPC-204-R-2001	**Instream habitat scored as 17, but silt/clay bottom with only 6 instream LWD/rootwads and described as a channelized ditch.** (Extensive floating vegetation, but is it a year-round habitat?). No flow.
UPPC-216-R-2001	UPPC-204 is ~700-800m downstream

UPPC-105-R-2001	DO=1.8
UPPC-113-R-2001	**another site is apparently 600 m upstream but comments say it is UPPC-113 (maybe UPPC-105?) Water quality measurements exactly the same at both UPPC-105 and UPPC-113, even though apparently 2.5 hours difference in time of sampling**; no flow
NASS-206-R-2001	Only 26 m of segment had water; no flow
NEWP-110-R-2001	Dry stream
DIVI-107-R-2001	Dry stream
DIVI-104-R-2001	Air bubble found under DO membrane– **DO NOT USE DO DATA FROM THIS SITE; should have used backup meter, even if taken the next day**; no measureable flow
DIVI-218-R-2001	**DO membrane had a bubble under it- do not use DO data from this site; should have used backup meter, even if taken the next day..**
WEBR-212-R-2001	
WEBR-104-R-2001	No flow; huge, unsampleable beaver pond
PAXM-120-R-2001	Clay/mud bottom
PAXM-114-R-2001	
GILB-115-R-2001	
GILB-213-R-2001	Little flow; pond upstream; high turbidity (50 NTU); no fish within segment but mudminnow collected below
ZEKI-118-R-2001	Standing pools and marsh; NPDES discharge (fly ash) upstream; DO= 0.4 ppm; pH= 5.17; No flow; no fish
ZEKI-307-R-2001	Removed beaver dam to sample fish; habitat sheet dirty- more difficult to photocopy
ZEKI-305-R-2001	
ZEKI-312-R-2001	
PRUT-106-R-2001	Lots of trash in stream

QC NOTE 9

SITE	**COMMENTS**
NANT-113-R-2001	**NOT SAMPLED- TURNS OUT PERMISSION WAS NOT GRANTED- PERMISSIONS FOLKS MAY HAVE MISINTERPRETED STREAM AS A PROPERTY BOUNDARY. ACTUAL LANDOWNER REFUSED PERMISSION TO COLLECT SUMMER SAMPLE**
NANT-114-R-2001	**Date hard to read- no writeovers**
NANT-311-R-2001	
SENE-119-R-2001	Dry
SENE-306-R-2001	
SENE-316-R-2001	
SENE-210-R-2001	Mostly shallow with little cover
SENE-211-R-2001	
SENE-205-R-2001	Moved site 25 meters upstream because of huge, unsampleable debris dam from 0-25m
SIDE-410-R-2001	
SIDE-405-R-2001	**6 Notropis sp. Collected but none retained- ALL unknowns should be retained**
SIDE-402-R-2001	
YOUG-110-R-2001	Sampled same reach ~110 m downstream in 1995
YOUG-107-R-2001	
YOUG-102-R-2001	Apparent bankfull event week prior to sampling and possibly dry before that
YOUG-219-R-2001	Stream out-of-bank 1 week prior to sampling
YOUG-214-R-2001	All substrate covered with fine layer of sediment

YOUG-118-R-2001	Closely ressembled an eastern shore site; impounded by beavers and near zero flow
YOUG-112-R-2001	pH = 4.96 likely due to acid deposition; top 24 meters was dry
PRUN-109-R-2001	Possibly within old beaverdam; **creek chub (s)-- shouldn't be plural**
PRUN-104-R-2001	New clear cut along right side of stream; pH=5.22 (acid dep probable cause for no fish)
PRUN-106-R-2001	
PRUN-103-R-2001	
PRUN-102-R-2001	Stream flows through and old beaver dam; fish movement noted during net installation; **anodes/unit not filled out**
PRUN-107-R-2001	
UPPC-115-R-2001	Near zero flow; channelized and runs through pasture
UPPC-410-R-2001	Mud stains on data sheet reduce usefulness of photocopied version
UPPC-118-R-2001	Less silt/clay than UPPC-103 which is ~700 m downstream
NASS-217-R-2001	Site moved 25 meters downstream because of deep pool at top of segment
PRAL-103-R-2001	Dry
DIVI-111-R-2001	**Really deep mud throughout segment, 3 of 4 thalweg depths fairly deep, and little flow-- but visibility listed as being same between passes. True?**

APPENDIX B

QA/QC Water Quality Report by

University of Maryland Center for Environmental Science

Appalachian Laboratory

Summary of Quality Assurance/Quality Control Results from

Spring 2000 Water Chemistry Analysis

for the Maryland Biological Stream Survey

April 2001

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Introduction

The primary objective of a good laboratory quality assurance plan is to ensure the quality of the data generated by the laboratory. Each method of analysis must then employ specific quality control steps to ensure data quality. To ensure attainment of the quality assurance objectives, standard operating procedures have been implemented that detail the requirements for the correct performance of analytical, or laboratory, procedures. The quality of all data generated and processed during the Spring 2000 Maryland Biological Stream Survey has been monitored for both precision and accuracy. The internal quality assurance/quality control protocols for chemical analysis followed guidelines from the "Handbook of Methods for Acid Deposition Studies: Laboratory Analyses for Surface Water Chemistry" (EPA, 1987).

Precision was determined by measuring the agreement among individual measurements of the same property, under similar conditions. Precision was assessed through the analysis of laboratory duplicates, or splits. The degree of agreement between replicates can be expressed as the percent relative standard deviation (RSD):

$$Percent\ RSD = \frac{SD}{X}\ X\ 100$$

Accuracy is defined as a measure of the closeness of an individual measurement to the true or expected value. Analyzing a reference material, or quality control check solution (QCCS), of known concentration is a method of determining accuracy. QCCS were independently made and analyzed after calibration, at specified intervals during sample analysis, and at the conclusion of sample analysis to ensure accurate measurement throughout analysis.

Deionized water blanks served as a check of laboratory-induced contamination. Laboratory blanks were analyzed at predetermined intervals as outlined in the standard operating procedures for each analyte.

Sample spikes were used with most of the analytical techniques to determine whether sample matrix affected analytical accuracy. A known concentration of analyte was added to about 15% of the samples. Both the spiked and unspiked samples were then analyzed. Percent recovery was calculated using the following equation:

$$\boxed{\%\,\mathrm{Spike\,Recovery} = \frac{\mathrm{spiked\,sample} - \mathrm{routine\,sample}}{\mathrm{spike\,amount\,(mg/L)}}\ X\ 100\%}$$

Percent recovery calculated for sample spikes should be within 15% of 100%.
An additional method employed by the laboratory to demonstrate quality of the chemical data was routine analysis of a field natural audit sample. The laboratory also participates annually in an inter-laboratory audit program.

The quality assurance plan in the analytical laboratory has yielded excellent results. A detailed description of the calibration and a summary of the quality control procedures and results for each analysis performed by the analytical laboratory at the University of Maryland Center Environmental Science Appalachian Laboratory in support of the 2000 Maryland Biological Stream Survey follows.

Analytes

Closed pH

The pH meter was calibrated using a set of three buffers with pH values of 4.00, 7.00 and 10.00. A quality control check solution (QCCS) with a theoretical pH value of 5.00 was then used to verify calibration. The measured value of the QCCS is required to be within 0.05 pH units. The QCCS was analyzed using the same procedures as for routine samples. If the QCCS was not within the acceptable range, then the solution was remade and analyzed again. If it failed to pass the second time, the meter was re-calibrated, and all samples that were measured since the last acceptable QCCS were re-analyzed. The average pH of all pH 5.00 QCCS analyzed in spring of 2000 was 4.98 (Table 1).

A laboratory blank was analyzed with each batch of samples. The average pH value for the lab blank was 5.52 (Table 2). The pH of laboratory blanks can be variable due to the nature of the matrix but it should typically be between 5.40 and 6.00, which brackets the normal equilibrium value of carbon dioxide and water.

Laboratory duplicates for closed pH were analyzed every ten samples. Acceptable precision criteria for pH require that duplicates be within 0.10 pH units of the routine sample analysis. Analysts achieve an average difference of 0.01 pH units (Table 3), which is within the acceptable precision limits for laboratory duplicate analysis for pH.

Acid Neutralizing Capacity (ANC)

Acid neutralizing capacity (ANC) was measured using the acidimetric Gran titration technique with electrometric pH detection. The pH meter used for the titration was calibrated using a set of two pH buffers that bracketed sample pH. A QCCS with a theoretical value of 5.00 was used to verify calibration. Any time that the QCCS was outside of the acceptable limits, the meter was re-calibrated and the QCCS was subsequently re-analyzed. The normality of the acid titrant was also cross-checked on a routine basis to verify method accuracy.

Prior to sample analysis a deionized water lab blank and sodium carbonate standards with a theoretical ANC of 200 or 50 μeq/L were analyzed to verify method and analyst accuracy. Standards with ANC's of 50 and 200 μeq/L were chosen because they most closely reflected the expected median sample median ANC. The average ANC of the 50 μeq/L QCCS was 49.2 μeq/L and the average for the 200 μeq/L QCCS was 196.7 μeq/L (Table 1). The accuracy goal for analysis of the QCCS for ANC is $\pm$ 5%. Whenever the QCCS was outside of the acceptable range, it usually indicated that the acid titrant was due to be re-standardized. The titrant was re-standardized and any samples from that batch were re-analyzed. The mean ANC for all blanks analyzed was 1.2 μeq/L, which is well below the acceptable limit of 10 μeq/L, and indicates an overall lack of contamination (Table 2). Laboratory duplicate analysis also yielded excellent precision results for ANC (Table 3).

Specific Conductance

Specific conductance was measured using a conductivity cell and meter with temperature compensation to 25˚C. Before sample analysis, the conductivity meter was subjected to an electronics check over the range of 1.0 μS/cm to 1000 μS/cm. This was used to verify that the meter was operating correctly. A series of calibration check solutions that bracketed the expected conductance values were then made and measured to check the calibration of the conductivity cell. A laboratory blank was also analyzed prior to sample analysis. If the initial conductance values of all of the calibration check solutions and the blank were within acceptable limits, sample analysis could proceed. The 74 μS/cm check solution was also measured every ten samples and all calibration check solutions were re-analyzed at the conclusion of sample analysis (Table 1). At the conclusion of sample analysis, if any of the sample measurements were higher than the highest calibration check solution, a higher calibration check solution was prepared and analyzed to verify the linear range of the technique. An average laboratory blank of 0.6 was well below the acceptance criteria of 1 μS/cm (Table 2). Laboratory duplicates were measured every ten samples and were required to be within one percent RSD. The average duplicate precision for specific conductance was 0.68 % RSD (Table 3).

Major Anions

Anions were measured using ion chromatography. Calibration for chloride, nitrate-nitrogen, and sulfate were conducted over at least a six point range, bracketing the expected concentrations of the ions of interest. Sample concentration was computed using peak area. The linear range of the calibration curve had to greater than 99.5 % before analysis of samples could be performed. Calibration plots of each analysis batch are archived at the Appalachian Laboratory.

A QCCS was measured at the beginning and the end of sample analysis. The QCCS had a theoretical value 2.0 mg/L. The mean values for the anion QCC were all within the recommended EPA quality assurance criteria for these analytes (Table 1). A laboratory blank was analyzed at the beginning of analysis. All blanks analyzed were below the detection limit for all three analytes (Table 2). Lab duplicate analysis was conducted approximately every ten samples. Duplicate laboratory analysis yielded an average percent RSD of 0.62 for chloride, 0.86 for nitrate-nitrogen, and 0.68 for sulfate (Table 3). These values verify that precision for the method was within acceptable limits. Matrix spike results for major anions suggest that sample matrix did not interfere with the analytical technique (Table 6). Average percent recovery values were within 15%.

Dissolved Organic Carbon

DOC was measured using the UV-persulfate oxidation methods. Calibration was conducted over a five point range, bracketing the expected DOC concentrations. Sample concentration was computed from instrument response using a calibration curve. The linear range of the calibration curve had to be greater than 99.5 percent before sample analysis could commence.

Check solutions were measured at the beginning of sample analysis and once every 20 samples. The solutions had theoretical values of 2 and 10 mg/L DOC. The average values for all check solutions analyzed were 2.10 mg/L for the 2 QCCS and 9.88 for the 10 QCCS (Table 1). Laboratory blanks were also well within acceptable limits for DOC (Table 2). Laboratory duplicates were analyzed once per sample batch and yielded a precision value of 3.30 percent RSD (Table 3). The acceptable limit of precision for DOC analysis is ten percent RSD.

Inorganic Nutrients

Nutrients were measured using colorimetric flow injection analysis techniques. Calibration for nitrite-nitrogen, ortho-phosphate, and ammonia were conducted over at least a five point range, bracketing the expected concentrations of the ions of interest. Sample concentration was computed using peak area. The linear range of the calibration curve had to greater than 99.5 % before analysis of samples could be performed. Calibration plots of each analysis batch are archived at the Appalachian Laboratory.

A QCCS was measured at the beginning and end of sample analysis, as well as at regular intervals. The QCCS had a theoretical value 0.05 mg/L. The mean values for the nutrient QCC were all within the recommended EPA quality assurance criteria for these analytes (Table 1). A laboratory blank was also analyzed at the beginning of analysis. All blanks analyzed were below or close to the detection limit for all three nutrients (Table 2). Lab duplicate analysis was conducted approximately every ten samples. Duplicate laboratory analysis yielded an average relative difference of <0.000 for nitrite, 0.001 for ortho-phosphate and 0.003 for ammonia (Table 3). These values verify that precision for the method was within acceptable limits. Matrix spike results for inorganic nutrients verify that sample matrix did not interfere with the analytical technique (Table 6). Average percent recovery values were within 15%.

Total Dissolved Nitrogen

Total dissolved nitrogen was measured on filtered samples using an in-line heat- and uv-assisted alkaline persulfate digestion technique. Calibration for total nitrogen was conducted over a five point range with nitrate standards that bracketed the expected sample concentrations. Sample concentration was computed using peak area. The linear range of the calibration curve had to greater than 99.5 % before analysis of samples could be performed. Calibration plots of each analysis batch are archived at the Appalachian Laboratory.

A QCCS was measured at the beginning and end of sample analysis, as well as at regular intervals. The QCCS had a theoretical value 0.5 mg/L and was prepared from a nitrite stock solution. By using nitrite for the source of the QC, this enabled the analyst to track cadmium column performance. The mean value for the nitrite QCC was within the recommended EPA quality assurance criteria (Table 1). Since this technique involved digestion of all nitrogen forms to nitrate, a digestion check solution of 0.9 mg/L was prepared from an ammonia standard as a check of digestion efficiency. The mean value for the digestion check standard was 0.829 mg/L, which is within recommended EPA QA criteria. A laboratory blank was also analyzed at the beginning of analysis (Table 2). Lab duplicate analysis was conducted approximately every ten samples. Duplicate laboratory analysis yielded an average precision of 1.74 % RSD (Table 3). Average percent recovery values for matrix spikes for TDN was 96.9 %, which is within the recommended 15% (Table 6).

Total Dissolved Phosphorus

Total dissolved phosphorus was measured on filtered samples using manual acidic persulfate digestion technique followed by colorimetric measurement by flow injection analysis. Standards, QC samples, blanks, and samples were all subjected to the same digestion procedure. Calibration for total phosphorus was conducted over a five point range with phosphate standards, bracketing the expected sample concentrations. Sample concentration was computed using peak area. The linear range of the calibration curve had to greater than 99.5 % before analysis of samples could be performed. Calibration plots of each analysis batch are archived at the Appalachian Laboratory.

A QCCS was measured at the beginning and end of sample analysis, as well as at regular intervals. The QCCS had a theoretical value 0.05 mg/L and was prepared from an independent phosphate stock solution. The mean values for the phosphate QCCS was well within the recommended EPA quality assurance criteria (Table 1). Since this technique involved conversion of all forms of phosphorus forms to phosphate for analysis, a digestion check of 0.2 mg/L was prepared from a sodium pyrophosphate standard as a check of digestion efficiency. The mean value for the digestion check standard was 0.183 mg/L, which is within 10% of the actual value. A laboratory blank was also analyzed at the beginning of analysis. All blanks analyzed were below or close to the detection limit (Table 2). Lab duplicate analysis was conducted approximately every ten samples. Duplicate laboratory analysis yielded an average percent RSD of 2.95(Table 3). These values verify that precision for the method was within acceptable limits. Average percent recovery values for matrix spikes for TDP was 98.4 %, which is within the recommended 15% (Table 6).

Particulate Phosphorus

Particulate phosphorus was collected on glass fiber filters. The samples were ashed at 550˚C and digested in 1.0 N hydrochloric acid. The supernatant was then analyzed for phosphate using colorimetric measurement by flow injection analysis. Calibration for particulate phosphorus was conducted over a five point range with phosphate standards, bracketing the expected sample concentrations. Sample concentration was computed using peak area. The linear range of the calibration curve had to greater than 99.5 % before analysis of samples could be performed. Calibration plots of each analysis batch are archived at the Appalachian Laboratory.

An independent 0.10 mg/L phosphate QCCS was measured at the beginning and end of sample analysis, as well as at regular intervals. The mean value for the phosphate QCC was within the recommended EPA quality assurance criteria (Table 1). Blank filters that had been carried through the same preparation procedure were also analyzed. The mean blank filter value for each analysis run was subtracted from each sample to correct for the filter. Lab duplicate analysis was conducted approximately every ten samples and yielded excellent precision results (Table 3). Average percent recovery values for matrix spikes for particulate phosphorus was 102.7 %, which is within the recommended 15% (Table 6).

Particulate Nitrogen

Particulate nitrogen was measured using 25-mm diameter glass fiber filters. The filters were combusted in tin capsules at 900˚C, which converts all particulate nitrogen to nitrogen oxide. The nitrogen oxides are then converted to molecular nitrogen and analyzed by thermal conductivity detection. The instrument was calibrated using approximately four separate acetanilide and/or atropine standards at weights expected to bracket instrument response for samples. Blank filters that had been carried through the same preparation procedure were also analyzed. The mean blank filter value for each analysis run was subtracted from each sample to correct for the filter concentration.

Acetanilide standard checks were analyzed between every 15-20 samples and at the end of each run. The average composition for nitrogen was 10.13%, which is within 10% of the actual composition value of 10.36% (Table 1). Lab duplicate analysis also yielded excellent precision results (Table 3).

Collection and Analysis of Natural Audit Sample

Natural audit samples are another useful part of a comprehensive Quality Assurance Plan. Because they are collected from streams, they are more representative of the actual sample matrix than a manufactured calibration check solution. In January of 1997, a field natural audit sample was collected from Upper Big Run in the Savage River State Forest in order to establish an internal audit sample (FNBR001). Approximately 50 liters of sample were filtered using a 0.45 μm filter capsule and a Masterflex pump. The sample was returned to the Appalachian laboratory where it was refrigerated for approximately 20 days and periodically check for stability by analyzing sample ANC. Once the sample was stable, it was poured off into 500 mL aliquots. The audit samples are stored in the dark at 4˚C and are analyzed periodically for all analytes except closed pH and aluminum. Although there are no actual right or wrong results for any of the analytes, as when a known QCCS is measured, variations in analyte concentration can help determine or diagnose any sources of analytical error. They are especially useful as a diagnostic tool when any changes in the operating conditions of an instrument (i.e., column or electrode replacement). Results from analysis of the audit sample verify the stability of the analytical results (Table 4).

Interlaboratory Audit

The laboratory also participates in the National Water Research Institute (NWRI) Ecosystem Interlaboratory Quality Assurance Program annually as an additional quality assurance measure. Twelve natural water samples were analyzed for the following analytes: open pH, specific conductance, DOC, ANC, nitrate-nitrogen, ammonia, total phosphorus, total nitrogen, sulfate, and chloride. Results from the Spring 2000 study were good with the laboratory receiving ideal ratings for six of the analytes (Table 5).

Table 1. Summary of QCCS analysis.

Analyte	Theoretical Value	Mean	N	Std. Dev.	Min.	Max.
Closed pH	5.00	4.98	129	0.02	4.95	5.02
ANC	200.0	196.7	35	6.5	185.6	213.2
	50.0	49.2	39	2.3	43.6	52.8
Conductance	14.7	14.8	34	0.43	13.4	15.8
	74.0	73.2	43	1.04	71.3	76.1
	147.0	145.0	34	2.23	140.1	149.1
Chloride	2.0	1.874	49	0.05	1.799	2.049
Nitrate-N	2.0	1.871	49	0.07	1.825	2.071
Sulfate	2.0	1.966	48	0.04	1.885	2.082
Nitrite-N	0.05	0.051	36	0.002	0.047	0.053
Ortho-phosphate	0.05	0.046	36	0.008	0.039	0.057
Ammonia	0.05	0.054	36	0.006	0.037	0.061
TDN	0.50	0.514	36	0.043	0.402	0.602
TDP	0.05	0.049	49	0.005	0.039	0.062
DOC	10.0	9.88	49	0.21	9.45	10.28
	2.0	2.10	48	0.12	1.86	2.42
PP	0.10	0.093	45	0.005	0.084	0.102
PN	10.36%	10.13	43	0.16	9.09	10.51

Table 2. Summary of laboratory blank analyses.

Analyte	Mean	N	Std. Dev.	Minimum	Maximum
Closed pH	5.52	47	0.19	5.29	6.15
ANC	1.2	33	2.7	-5.0	8.6
Conductance	0.6	18	0.2	0.3	0.9
Chloride	0.003	20	0.01	0	0.06
Nitrate-N	0	20	0	0	0
Sulfate	0	20	0	0	0
Nitrite-N	0	21	<0.001	-0.0002	0.0001
Ortho-PO4	0.0019	21	0.002	-0.0013	0.0071
Ammonia	-0.0009	21	0.010	-0.0192	0.0192
TDN	0.0178	20	0.062	-0.080	0.232
TDP	0.0028	13	0.001	0.0007	0.0043
DOC	0.080	9	0.038	0.020	0.124
PP	0.0014	11	<0.001	0.0009	0.0016

Table 3. Summary of precision analysis for the project. Values are in percent relative standard deviation (% RSD) unless otherwise noted.

Analyte	Average Precision	N	Std. Dev.
Closed pH	0.01 units	54	0.04
ANC	1.01	39	2.98
Conductance	0.68	42	0.87
Chloride	0.62	33	0.77
Nitrate-N	0.86	31	0.93
Sulfate	0.68	33	0.72
Nitrite-N	<0.000 mg/L	21	<0.000
Ortho-PO4	0.001 mg/L	21	0.002
Ammonia	0.003 mg/L	21	0.010
TDN	1.74	25	1.57
TDP	2.95	33	2.60
DOC	3.30	41	3.08
PP	1.93	23	2.17
PN	3.76	32	3.33

Table 4. Natural audit sample analytical results.

Analyte	Mean	N	Std. Dev.	Minimum	Maximum
ANC	35.8	22	3.22	30.2	44.7
Conductance	28.8	17	1.13	26.3	30.7
Chloride	0.785	19	0.04	0.749	0.943
Nitrate-N	0.166	19	0.06	0.143	0.429
Sulfate	7.150	18	0.07	7.043	7.327
DOC	0.660	10	0.05	0.585	0.723

Table 5. Summary of results from 2000 NWRI interlaboratory audit.

Analyte	Rating
Conductance	Ideal
Open pH	Ideal
DOC	Ideal
ANC	Flagged high on 1 sample
Nitrate-N	Flagged low on 3 samples
Ammonia	Flagged low on 3 samples
Total Phosphorus	Ideal
Total Nitrogen	Ideal
Sulfate	Ideal
Chloride	Flagged low on 1 sample

Table 6. Summary of percent recovery results from sample spike analysis.

Analyte	Mean	N	Std. Dev.	Minimum	Maximum
Nitrite-N	104.0	28	4.0	92.9	112.6
Ortho-phosphate	101.9	28	7.2	85.6	114.0
Ammonia-N	105.5	28	4.7	94.5	115.1
Chloride	102.0	27	7.1	84.5	118.5
Nitrate-N	99.5	28	15.9	87.0	115.3
Sulfate	95.5	30	12.6	85.3	103.8
TDN	96.9	12	6.7	85.1	109.3
TDP	98.4	20	2.8	92.5	103.4
PP	102.7	16	8.6	89.1	116.7

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Environmental Protection Agency. 1987. Handbook of methods for acid deposition studies: Laboratory analysis for surface water chemistry. United States Environmental Protection Agency, Acid Deposition and Atmospheric Research Division, Office of Acid Deposition, Environmental Monitoring and Quality Assurance, Office of Research and Development, Washington, D.D. EPA-600/4-87/026.

APPENDIX C

Benthic Taxa Lists for Sites

With Duplicate Field Samples

BALT-207-R-2001

Taxon	Original Data	Duplicate Data
Ancyronyx	1.75	1.80
Apsectrotanypus	0.00	0.90
Calopteryx	0.88	0.90
Calopteryx	0.00	0.90
Clinotanypus	0.00	2.70
CORIXIDAE	2.63	2.70
Corynoneura	0.00	0.90
Cricotopus/Orthocladius	16.67	6.31
Cryptochironomus	0.00	0.90
Dicrotendipes	1.75	1.80
Dubiraphia	0.88	0.00
Enallagma	0.88	0.00
Endochironomus	4.39	0.00
Eurylophella	0.00	0.90
Gyrinus	0.00	1.80
Hyalella	20.18	36.94
Hydroporus	0.88	0.00
Limnodrilus	1.75	0.00
LUMBRICULIDAE	0.88	0.00
Meropelopia	7.89	9.91
Micropsectra	12.28	7.21
Paralauterborniella	0.00	0.90
Paramerina	0.00	2.70
Parametriocnemus	8.77	5.41
Paratanytarsus	7.02	0.00
Phaenopsectra	0.88	0.00
Physella	0.00	2.70
Polycentropus	0.00	0.90
Procladius	0.00	1.80
Promenetus	0.88	0.00
Prostoma	0.88	0.00
Ptilostomis	0.88	0.00
Somatochlora	0.88	0.00
Thienemanniella	0.88	0.00
SPHAERIIDAE	0.00	0.90
Stenelmis	0.00	0.90
TIPULIDAE	0.88	2.70
Triaenodes	0.88	0.00
TUBIFICIDAE	3.51	3.60
Unniella	0.00	0.90

DEER-106-R-2001

Taxon	Original Data	Duplicate Data
Boyeria	0.68	0.00
Brillia	0.00	1.01
Conchapelopia	1.37	1.01
Corynoneura	0.68	0.00
Cricotopus/Orthocladius	1.37	0.00
Diamesa	0.68	0.00
Enochrus	0.68	0.00
Ephemerella	0.68	0.00
Eurylophella	0.68	1.01
Helichus	0.68	0.00
Hemerodromia	0.00	1.01
LEPTOPHLEBIIDAE	0.68	0.00
Micropsectra	0.00	2.02
NEMOURIDAE	4.11	5.05
Neophylax	0.68	0.00
Parametriocnemus	4.11	2.02
Prosimulium	70.55	78.79
Prostoia	4.11	0.00
Pseudolimnophila	1.37	0.00
Pycnopsyche	0.00	1.01
Stegopterna	1.37	0.00
Sympotthastia	0.00	6.06
Tallaperla	0.68	1.01
Tanytarsus	2.05	0.00
Tipula	0.68	0.00
Trissopelopia	0.68	0.00
TUBIFICIDAE	0.68	0.00
Zavrelimyia	0.68	0.00

DIVI-111-R-2001

Taxon	Original Data	Duplicate Data
Apsectrotanypus	0.00	4.67
Caecidotea	0.00	1.87
Clinotanypus	0.00	4.67
COENAGRIONIDAE	0.00	1.87
Conchapelopia	0.00	21.50
Corynoneura	0.94	0.00
Cricotopus/Orthocladius	1.89	9.35
Dicrotendipes	0.00	2.80
Dubiraphia	1.89	0.00
Dugesia	1.89	0.00
Enallagma	2.83	0.00
Eurylophella	8.49	7.48
GORDIIDAE	0.94	0.00
Hemerodromia	1.89	0.00
Labrundinia	2.83	0.00
Leptophlebia	27.36	27.10
LUMBRICULIDAE	0.00	0.93
Meropelopia	16.04	0.00
Nanocladius	1.89	0.93
ORTHOCLADIINAE	0.00	1.87
Oxyethira	0.94	0.00
Phaenopsectra	6.60	0.00
Polycentropus	0.94	0.00
Procambarus	0.00	0.93
Rheotanytarsus	9.43	2.80
Sialis	0.94	0.00
SIMULIIDAE	0.94	0.00
Synurella	0.00	4.67
TANYPODINAE	0.00	0.93
Triaenodes	0.94	0.00
Tribelos	1.89	0.93
Unniella	6.60	4.67
Zalutschia	1.89	0.00

GILB-109-R-2001

Taxon	Original Data	Duplicate Data
Amphinemura	0.00	0.87
Caecidotea	1.63	0.00
Ceratopogon	0.81	0.00
CERATOPOGONIDAE	0.00	0.87
Cheumatopsyche	0.81	0.00
Chrysops	2.44	0.00
Endochironomus	0.00	1.74
Hemerodromia	0.81	0.00
Hexatoma	0.81	0.00
LEPTOPHLEBIIDAE	4.07	0.00
LIMNEPHILIDAE	0.00	0.87
Meropelopia	10.57	6.09
Micropsectra	0.00	2.61
Parametriocnemus	51.22	53.91
Pycnopsyche	9.76	2.61
Simulium	0.00	0.87
SPHAERIIDAE	1.63	0.87
Stegopterna	13.82	26.96
Synurella	1.63	0.00
Thienemanniella	0.00	1.74

LIGU-201-R-2001

Taxon	Original Data	Duplicate Data
Acroneuria	0.75	0.00
Antocha	0.75	1.39
Argia	0.00	0.69
BAETIDAE	0.00	0.69
Cheumatopsyche	6.77	4.86
Chimarra	1.50	0.69
Conchapelopia	3.76	2.78
Cricotopus/Orthocladius	1.50	2.78
Diamesa	0.00	2.08
Dicranota	0.00	0.69
DOLICHOPODIDAE	0.75	0.00
Dubiraphia	0.75	0.00
Ephemerella	1.50	5.56
Eukiefferiella	0.75	2.08
Eurylophella	1.50	0.00
Helichus	0.00	0.69
Hemerodromia	0.75	0.00
Hydropsyche	3.76	4.17
LEPTOPHLEBIIDAE	0.00	1.39
LUMBRICULIDAE	0.00	0.69
Macronychus	0.00	1.39
Microtendipes	0.00	0.69
Nanocladius	1.50	1.39
Neophylax	1.50	0.00
Oemopteryx	0.00	2.08
Optioservus	0.75	0.69
Orthocladius	0.00	2.08
Oulimnius	0.75	0.00
Pagastia	0.75	0.00
Parametriocnemus	17.29	17.36
PERLIDAE	0.75	0.00
Prosimulium	5.26	7.64
Prostoia	15.79	7.64
Psephenus	0.00	0.69
Rheotanytarsus	1.50	1.39
Serratella	0.75	0.00
Simulium	2.26	1.39
Stenelmis	1.50	0.00
Stenonema	6.77	2.08
Strophopteryx	3.01	11.11
Sympotthastia	1.50	4.86
Taeniopteryx	4.51	0.00
Tanytarsus	1.50	0.00
Thienemanniella	0.75	0.69
Tvetenia	6.77	5.56

NEWP-110-R-2001

Taxon	Original Data	Duplicate Data
Caecidotea	1.72	14.88
Chauliodes	0.00	0.83
Crangonyx	1.72	19.01
Heterotrissocladius	1.72	0.00
Hydrobaenus	3.45	6.61
Ironoquia	0.00	0.83
Isotomurus	0.00	2.48
LIMNEPHILIDAE	0.00	1.65
LUMBRICULIDAE	0.00	1.65
Menetus	0.00	5.79
Meropelopia	0.00	0.83
Mesocricotopus	0.00	1.65
Orthocladius	0.00	9.92
Rheocricotopus	0.00	3.31
Sphaerium	87.07	23.97
Stagnicola	1.72	0.83
Synurella	0.00	3.31
Tribelos	1.72	2.48
TUBIFICIDAE	0.86	0.00

PAXM-107-R-2001

Taxon	Original Data	Duplicate Data
Antocha	0.00	0.85
BRACONIDAE	0.00	0.85
Brillia	1.69	0.00
Caecidotea	0.85	3.39
Chaetocladius	0.00	0.85
Chelifera	0.00	1.69
CHIRONOMINI	9.32	0.85
CRANGONYCTIDAE	0.00	0.85
Crangonyx	0.00	0.85
Cricotopus/Orthocladius	10.17	13.56
DYTISCIDAE	0.85	0.00
ENCHYTRAEIDAE	0.00	0.85
Eukiefferiella	5.08	3.39
Hemerodromia	1.69	0.00
Hydrobius	0.00	0.85
Hydropsyche	0.85	0.00
LIMNEPHILIDAE	0.00	0.85
Limnodrilus	1.69	0.00
LUMBRICULIDAE	4.24	0.85
Lype	0.85	0.00
NAIDIDAE	0.00	0.85
Nigronia	1.69	0.85
ORTHOCLADIINAE	1.69	0.85
Parametriocnemus	36.44	39.83
Phaenopsectra	0.85	0.00
Polypedilum	4.24	5.93
Prodiamesa	0.85	0.00
Rheocricotopus	5.93	8.47
Sphaerium	0.00	0.85
Stegopterna	3.39	1.69
TANYPODINAE	0.00	3.39
Tipula	6.78	4.24
TIPULIDAE	0.00	0.85
TUBIFICIDAE	0.85	1.69

PRAL-208-R-2001

Taxon	Original Data	Duplicate Data
Acroneuria	0.00	0.78
Ameletus	2.68	8.53
Amphinemura	10.71	3.88
CHLOROPERLIDAE	4.46	0.78
Conchapelopia	2.68	10.85
Cricotopus/Orthocladius	0.00	0.78
Diplectrona	0.00	1.55
Ephemerella	24.11	22.48
HEPTAGENIIDAE	5.36	11.63
Lepidostoma	1.79	0.00
LEUCTRIDAE	5.36	2.33
LUMBRICULIDAE	0.00	0.78
Micropsectra	5.36	0.00
Neophylax	0.89	4.65
Nigronia	0.00	0.78
Paraleptophlebia	4.46	3.88
Parametriocnemus	0.89	1.55
PERLODIDAE	2.68	3.10
PHILOPOTAMIDAE	0.89	0.00
Prosimulium	25.00	0.00
Rhyacophila	1.79	0.00
Simulium	0.00	15.50
Tanytarsus	0.00	5.43
Tipula	0.00	0.78
Tvetenia	0.89	0.00

SENE-114-R-2001

Taxon	Original Data	Duplicate Data
Ameletus	0.96	0.00
Brillia	2.88	5.66
Cheumatopsyche	6.73	1.89
Clinocera	3.85	1.89
Cricotopus/Orthocladius	0.00	0.94
Diamesa	0.00	0.94
Diplectrona	4.81	3.77
GOMPHIDAE	0.96	0.00
Hemerodromia	1.92	0.00
Heterotrissocladius	0.00	0.94
Hydropsyche	0.96	0.94
LIMNEPHILIDAE	0.96	0.00
Meropelopia	3.85	3.77
Microtendipes	0.00	0.94
NAIDIDAE	0.96	0.00
Nanocladius	0.00	0.94
Optioservus	0.96	7.55
Parametriocnemus	4.81	0.00
Polypedilum	54.81	47.17
Rheotanytarsus	2.88	0.00
Stegopterna	0.96	0.94
Stictochironomus	0.96	15.09
Thienemanniella	0.96	0.94
Tipula	1.92	1.89
Trissopelopia	0.00	0.94
Tvetenia	2.88	2.83

STIL-109-R-2001

Taxon	Original Data	Duplicate Data
Amnicola	0.75	0.00
AMPHIPODA	0.00	0.87
Caecidotea	9.70	13.04
Chaetocladius	2.99	0.87
Chelifera	0.00	0.87
Cheumatopsyche	0.75	2.61
CHIRONOMIDAE	0.00	0.87
CHIRONOMINI	1.49	0.00
Conchapelopia	4.48	0.00
Corynoneura	1.49	0.87
Cricotopus/Orthocladius	16.42	10.43
Dicrotendipes	0.00	0.87
Dubiraphia	0.75	4.35
Dugesia	0.75	0.87
Gammarus	0.00	1.74
Hexatoma	0.75	0.00
Hyalella	17.16	17.39
Hydroporus	1.49	0.00
Ironoquia	0.75	0.87
Leptophlebia	0.00	0.87
LUMBRICULIDAE	1.49	0.00
Nanocladius	0.00	0.87
Parametriocnemus	0.00	3.48
Paratanytarsus	0.75	0.00
Phaenopsectra	0.75	2.61
Physella	2.24	3.48
Polypedilum	1.49	0.87
Procladius	0.75	0.00
Pseudolimnophila	0.75	0.00
Rheocricotopus	5.97	3.48
Rheotanytarsus	3.73	4.35
Sphaerium	0.00	1.74
Stegopterna	0.75	3.48
Symposiocladius	2.24	0.87
Synurella	1.49	0.87
TANYPODINAE	10.45	1.74
TANYTARSINI	0.75	0.87
Tanytarsus	0.00	3.48
Thienemanniella	0.75	0.87
Thienemannimyia group	2.24	2.61
TIPULIDAE	0.00	0.87
Tribelos	0.00	2.61
TUBIFICIDAE	0.75	3.48
Xylotopus	2.24	0.00
Zavrelimyia	0.75	0.00

UPPC-101-R-2001

Taxon	Original Data	Duplicate Data
Aedes	0.00	0.96
Agabus	0.00	0.96
Boyeria	0.00	0.96
Caecidotea	13.00	17.31
Corynoneura	4.00	0.00
Crangonyx	12.00	1.92
Endochironomus	5.00	0.00
Ironoquia	0.00	3.85
LIMNEPHILIDAE	2.00	0.00
Limnophyes	0.00	0.96
LUMBRICULIDAE	4.00	5.77
Mesosmittia	0.00	0.96
ORTHOCLADIINAE	0.00	0.96
POLYCENTROPODIDAE	1.00	0.00
Polypedilum	6.00	5.77
Polypedilum	0.00	3.85
Pseudolimnophila	1.00	0.96
Rheocricotopus	3.00	0.00
Stilocladius	0.00	2.88
Synurella	10.00	15.38
Tribelos	39.00	36.54

WEBR-106-R-2001

Taxon	Original Data	Duplicate Data
Cheumatopsyche	0.00	1.72
Cricotopus/Orthocladius	14.55	16.38
Ironoquia	0.00	0.86
LUMBRICULIDAE	0.91	0.86
Meropelopia	0.00	0.86
Parametriocnemus	1.82	0.00
Physella	0.91	0.86
Prostoia	3.64	8.62
Rheocricotopus	0.91	0.00
Sphaerium	0.00	0.86
Simulium	0.91	0.00
Stegopterna	75.45	66.38
TUBIFICIDAE	0.91	2.59

YOUG-101-C-2001

Taxon	Original Data	Duplicate Data
Amphinemura	0.81	0.81
BAETIDAE	0.81	0.81
Baetis	6.50	4.88
Chelifera	0.81	0.81
CHIRONOMIDAE	1.63	1.63
CHIRONOMINI	0.81	7.32
Corynoneura	0.81	1.63
Cricotopus/Orthocladius	0.00	0.81
Dicranota	0.81	1.63
Diplectrona	0.81	0.00
ENCHYTRAEIDAE	1.63	0.00
Ephemerella	4.88	3.25
Eukiefferiella	14.63	19.51
Heterotrissocladius	0.81	0.00
Hexatoma	0.00	0.81
Hydropsyche	0.81	0.00
Isoperla	0.81	0.00
LEUCTRIDAE	0.00	0.81
Micropsectra	3.25	11.38
NAIDIDAE	0.81	0.00
Nanocladius	0.81	0.81
Neophylax	2.44	4.88
Nigronia	0.81	1.63
ORTHOCLADIINAE	2.44	3.25
Orthocladius	0.81	0.00
Paraleptophlebia	1.63	0.00
Parametriocnemus	7.32	6.50
PERLODIDAE	1.63	1.63
Polypedilum	1.63	0.00
Prosimulium	11.38	3.25
Rhyacophila	4.07	0.81
Serratella	0.00	0.81
Stempellina	0.00	0.81
Stenacron	0.81	0.00
Stenonema	0.00	0.81
Tallaperla	0.81	0.81
TANYPODINAE	0.81	0.00
TANYTARSINI	19.51	8.94
Tanytarsus	0.00	3.25
Thienemannimyia group	0.00	2.44
Tipula	0.81	0.00
Trissopelopia	0.81	3.25

YOUG-106-R-2001

Taxon	Original Data	Duplicate Data
Ameletus	2.73	0.00
Amphinemura	11.82	16.10
BAETIDAE	5.45	0.85
Baetis	4.55	3.39
BRANCHIOBDELLIDA	0.91	0.00
Chelifera	0.91	0.00
CHLOROPERLIDAE	0.91	0.00
Cinygmula	0.91	0.00
Cricotopus/Orthocladius	0.91	0.00
Diamesa	0.91	0.00
Dicranota	1.82	0.85
Diplectrona	1.82	3.39
Dolophilodes	7.27	0.00
Epeorus	0.91	0.85
Ephemerella	2.73	2.54
HEPTAGENIIDAE	0.91	0.85
Isoperla	3.64	2.54
Leuctra	0.00	1.69
LEUCTRIDAE	3.64	8.47
NAIDIDAE	0.91	0.85
Neophylax	0.00	0.85
ORTHOCLADIINAE	2.73	1.69
Oulimnius	0.91	0.00
Paraleptophlebia	0.91	1.69
Parametriocnemus	1.82	2.54
PERLODIDAE	2.73	0.00
Prosimulium	28.18	38.98
Pteronarcys	0.91	0.85
Rhyacophila	1.82	0.85
Sweltsa	0.00	0.85
Tallaperla	0.91	0.85
TANYTARSINI	0.00	0.85
Tanytarsus	0.00	0.85
Thienemannimyia group	0.00	0.85
Tipula	0.91	0.00
TRICHOPTERA	0.91	0.85
Tvetenia	2.73	4.24
Wormaldia	0.91	0.85

YOUG-221-R-2001

Taxon	Original Data	Duplicate Data
Acroneuria	0.00	0.85
Amphinemura	2.27	1.71
BAETIDAE	0.00	2.56
Baetis	13.64	17.09
Brillia	0.00	0.85
Chelifera	0.76	0.85
Cheumatopsyche	0.00	0.85
CHIRONOMINAE	0.76	0.00
CHLOROPERLIDAE	1.52	0.00
Clioperla	0.76	0.00
Cricotopus/Orthocladius	1.52	1.71
Dicranota	0.76	1.71
Diplectrona	0.00	1.71
Dolophilodes	1.52	0.00
ENCHYTRAEIDAE	1.52	0.00
Epeorus	9.09	10.26
Ephemerella	5.30	3.42
HEPTAGENIIDAE	0.00	0.85
Hexatoma	0.00	0.85
Hydropsyche	0.76	3.42
HYDROPSYCHIDAE	0.00	0.85
Isoperla	1.52	0.85
Leuctra	1.52	0.00
LEUCTRIDAE	1.52	3.42
Micropsectra	0.00	0.85
Molophilus	0.76	0.00
Neophylax	0.76	0.85
Oemopteryx	7.58	2.56
ORTHOCLADIINAE	6.82	2.56
Oulimnius	1.52	3.42
Paraleptophlebia	0.00	1.71
Parametriocnemus	12.88	10.26
PERLIDAE	2.27	0.00
PERLODIDAE	0.76	0.00
Polypedilum	6.06	3.42
Prosimulium	6.06	9.40
Pteronarcys	1.52	0.85
Rhyacophila	0.00	0.85
Serratella	0.76	0.00
Stenonema	1.52	0.00
Tallaperla	3.03	0.85
TANYTARSINI	0.76	1.71
Thienemannimyia group	0.00	0.85
TRICHOPTERA	0.76	0.00
Tvetenia	1.52	5.98

ZEKI-103-R-2001

Taxon	Original Data	Duplicate Data
Amphinemura	2.83	0.00
Caecidotea	17.92	13.82
Ceratopogon	0.00	0.81
Corynoneura	0.94	0.00
Crangonyx	0.00	2.44
Cura	0.94	0.00
Cricotopus/Orthocladius	0.00	2.44
Diplocladius	0.94	0.81
Eukiefferiella	0.94	0.00
GORDIIDAE	1.89	0.00
Hexatoma	1.89	0.00
Hydrobaenus	1.89	0.00
Isotomurus	0.94	0.00
LEUCTRIDAE	0.00	1.63
LIMNEPHILIDAE	4.72	8.13
Meropelopia	3.77	4.07
NEMOURIDAE	2.83	1.63
ORTHOCLADIINAE	0.94	0.00
Parametriocnemus	2.83	0.81
POLYCENTROPODIDAE	1.89	0.00
Prosimulium	12.26	16.26
Pseudolimnophila	0.00	0.81
Pycnopsyche	0.94	0.00
Rheocricotopus	0.00	4.07
Rhyacophila	0.94	0.81
SPHAERIIDAE	1.89	0.81
Spirosperma	4.72	0.81
Stegopterna	16.04	29.27
Synurella	12.26	9.76
Tipula	1.89	0.00
TUBIFICIDAE	0.94	0.00
Zavrelimyia	0.00	0.81

ZEKI-215-R-2001

Taxon	Original Data	Duplicate Data
Acerpenna	6.29	12.15
Boyeria	0.00	0.93
Caecidotea	0.00	4.67
Cheumatopsyche	0.70	0.93
CHIRONOMINI	0.70	0.00
CHLOROPERLIDAE	11.89	9.35
Chrysops	0.00	0.93
Corynoneura	0.00	0.93
Culicoides	0.00	0.93
Diplectrona	0.70	0.00
Eccoptura	1.40	4.67
Ephemerella	6.99	0.00
Eurylophella	0.70	0.00
Heleniella	1.40	4.67
HEPTAGENIIDAE	0.00	0.93
Hexatoma	0.00	2.80
Hydatophylax	0.70	0.93
LEUCTRIDAE	0.70	0.00
LUMBRICULIDAE	0.00	1.87
Lype	0.00	1.87
Macronychus	0.00	0.93
Meropelopia	0.00	0.93
Microtendipes	0.00	0.93
Neophylax	0.00	0.93
Optioservus	0.70	2.80
Oulimnius	2.80	0.00
Parametriocnemus	2.10	2.80
PERLIDAE	0.00	0.93
Physella	0.70	0.00
Polypedilum	0.00	0.93
Probezzia	0.00	3.74
Prosimulium	55.94	0.00
Ptilostomis	0.70	0.00
Rheocricotopus	0.00	0.93
Rheotanytarsus	0.00	2.80
Siphloplectron	0.00	7.48
SPHAERIIDAE	0.00	0.93
Spirosperma	0.00	1.87
Stenonema	1.40	0.00
Stylogomphus	0.70	0.00
Symposiocladius	0.00	0.93
Synurella	0.00	2.80
TANYTARSINI	0.70	0.00
Tanytarsus	0.00	1.87
Thienemanniella	0.00	0.93
Tipula	0.00	6.54
Trissopelopia	0.00	1.87
Tvetenia	2.10	0.93
Xylotopus	0.00	0.93
Zavrelimyia	0.00	5.61

ZEKI-302-R-2001

Taxon	Original Data	Duplicate Data
Ablabesmyia	0.79	0.00
Acerpenna	0.00	1.57
Bezzia	1.57	0.00
Brillia	0.79	0.79
Caecidotea	2.36	0.79
Cheumatopsyche	1.57	2.36
Conchapelopia	0.00	0.79
Cricotopus	2.36	0.00
Cricotopus/Orthocladius	9.45	24.41
Eurylophella	1.57	0.79
Isoperla	0.00	17.32
LIMNEPHILIDAE	0.00	0.79
LIMNEPHILIDAE	3.15	2.36
Meropelopia	2.36	0.00
NEMOURIDAE	5.51	0.00
Neophylax	0.79	0.00
Oulimnius	0.00	0.79
Parametriocnemus	2.36	0.00
PERLODIDAE	22.83	0.00
Prosimulium	29.92	24.41
Rheotanytarsus	0.00	3.15
Rhyacophila	2.36	0.00
Stegopterna	0.79	0.79
Stempellinella	0.00	0.79
Stenelmis	0.00	2.36
Stenonema	0.79	5.51
Strophopteryx	0.00	0.79
Synurella	0.79	6.30
TAENIOPTERYGIDAE	1.57	0.00
Taeniopteryx	1.57	0.00
Tanytarsus	2.36	0.79
Triaenodes	0.79	2.36
Tvetenia	1.57	0.00

ZEKI-307-R-2001

Taxon	Original Data	Duplicate Data
Ablabesmyia	0.93	0.00
Acerpenna	0.93	0.00
BAETIDAE	0.00	0.83
Brillia	0.00	0.83
Calopteryx	0.93	0.00
Ceratopogon	0.00	0.83
Cheumatopsyche	3.74	7.50
Clinotanypus	0.00	0.83
Clioperla	0.00	0.83
Crangonyx	1.87	0.00
Culicoides	0.00	3.33
Eukiefferiella	0.00	0.83
Eurylophella	1.87	0.00
GOMPHIDAE	1.87	0.00
Hemerodromia	1.87	0.00
Hydatophylax	0.00	1.67
Hydropsyche	0.93	0.00
Isoperla	1.87	1.67
LEPTOPHLEBIIDAE	0.00	1.67
LUMBRICULIDAE	0.93	2.50
Lype	0.00	1.67
Meropelopia	0.00	5.83
Microtendipes	0.93	10.83
Molannodes	0.93	0.00
Parametriocnemus	1.87	0.00
Phaenopsectra	2.80	0.00
Physella	0.00	0.83
Procladius	0.00	0.83
Prosimulium	53.27	16.67
Psilotreta	0.00	0.83
Rheotanytarsus	11.21	9.17
Stegopterna	0.93	1.67
Stempellinella	0.00	4.17
Stenonema	1.87	3.33
Synurella	0.00	8.33
Tanytarsus	3.74	5.83
Tipula	0.00	0.83
Triaenodes	0.00	0.83
Tribelos	0.00	1.67
Trissopelopia	0.93	0.00
TUBIFICIDAE	1.87	2.50
Tvetenia	1.87	0.83

APPENDIX D

Benthic Taxa Lists for Sites

With Duplicate Laboratory Samples

BALT-202-R-2001

Taxon	Duplicate Data	Original Data
Argia	0.91	1.01
Belostoma	0.91	0.00
Brillia	0.00	1.01
Calopteryx	0.00	2.02
CHIRONOMIDAE	0.00	4.04
CHIRONOMINI	0.00	5.05
Corynoneura	0.00	1.01
Cricotopus/Orthocladius	0.00	21.21
Culicoides	0.00	1.01
Dubiraphia	0.00	1.01
Gammarus	49.09	39.39
Helichus	0.00	1.01
Hemerodromia	0.00	1.01
Hydropsyche	0.00	1.01
Isotomidae	0.91	0.00
Isotomurus	0.00	2.02
Limnodrilus	0.00	1.01
LUMBRICULIDAE	0.00	2.02
Macronychus	0.00	1.01
OLIGOCHAETA	5.45	0.00
ORTHOCLADIINAE	28.18	0.00
Phylocentropus	0.00	1.01
Physella	0.91	0.00
Polycentropus	1.82	0.00
Ptilostomis	0.91	0.00
Sialis	0.91	1.01
TANYPODINAE	1.82	0.00
TANYTARSINI	4.55	4.04
Triaenodes	3.64	3.03
TUBIFICIDAE	0.00	5.05

GILB-114-R-2001

Taxon	Duplicate Data	Original Data
Caecidotea	2.80	1.74
Caecidotea	0.00	0.87
Ceratopogon	0.00	3.48
CHIRONOMIDAE	0.00	0.87
CHIRONOMINI	0.00	0.87
Dicranota	0.00	0.87
Hemerodromia	4.67	0.00
LEPTOPHLEBIIDAE	0.00	5.22
LIMNEPHILIDAE	0.93	3.48
Neophylax	0.00	0.87
ORTHOCLADIINAE	59.81	51.30
Physella	0.93	0.00
Simulium	1.87	2.61
SPHAERIIDAE	1.87	21.74
Stegopterna	16.82	0.87
Synurella	1.87	0.00
TANYPODINAE	2.80	1.74
TANYTARSINI	1.87	2.61
Tipula	3.74	0.87

NASS-211-R-2001

Taxon	Duplicate Data	Original Data
Caecidotea	2.54	5.36
Calopteryx	0.85	0.89
Cheumatopsyche	6.78	1.79
CHIRONOMIDAE	0.00	4.46
CHIRONOMINI	0.85	5.36
Chrysops	0.00	0.89
Crangonyx	2.54	5.36
Dineutus	0.85	0.00
Hyalella	0.00	1.79
Leptophlebia	15.25	13.39
LIMNEPHILIDAE	0.85	1.79
LUMBRICULIDAE	0.85	0.89
Menetus	0.85	0.00
Oecetis	0.85	0.00
ORTHOCLADIINAE	11.86	7.14
Physella	0.00	0.89
Placobdella	0.00	0.89
SCIRTIDAE	0.00	1.79
Simulium	16.10	13.39
SPHAERIIDAE	2.54	0.00
Stegopterna	20.34	14.29
Stenacron	0.85	0.00
Stenonema	0.00	1.79
Synurella	5.93	2.68
Taeniopteryx	1.69	8.04
TANYPODINAE	4.24	0.89
TANYTARSINI	2.54	5.36
Triaenodes	0.85	0.00
Zalutschia	0.00	0.89

NEAS-201-R-2001

Taxon	Duplicate Data	Original Data
Ameletus	1.57	0.00
Atherix	0.79	0.00
Caenis	0.00	2.88
Cheumatopsyche	0.00	1.92
CHIRONOMIDAE	0.00	0.96
Clinocera	3.15	1.92
DIAMESINAE	0.79	2.88
Dicrotendipes	0.00	0.96
Ephemerella	23.62	25.00
Eurylophella	9.45	8.65
Hydropsyche	2.36	2.88
HYDROPSYCHIDAE	0.79	0.00
Hydroptila	0.79	0.00
Isonychia	1.57	0.00
NEMOURIDAE	2.36	0.00
Neophylax	2.36	0.00
ORTHOCLADIINAE	22.83	25.00
Polycentropus	0.79	0.00
Prosimulium	18.90	13.46
Prostoia	0.00	4.81
Psephenus	0.00	1.92
Stenelmis	0.79	0.00
Stenonema	3.15	1.92
Strophopteryx	0.79	1.92
TANYPODINAE	0.00	1.92
TANYTARSINI	2.36	0.96
Tipula	0.79	0.00

PAXM-119-R-2001

Taxon	Duplicate Data	Original Data
Caecidotea	8.26	10.19
Caenis	0.92	0.00
Calopteryx	1.83	1.85
Cheumatopsyche	2.75	4.63
CHIRONOMIDAE	0.00	3.70
CHIRONOMINI	0.00	0.93
Dicranota	0.92	2.78
Diplectrona	1.83	1.85
Hexatoma	2.75	0.93
Hydroporus	2.75	1.85
Hydropsyche	2.75	2.78
LIMNEPHILIDAE	0.00	0.93
Limnodrilus	0.00	4.63
Lype	0.00	1.85
Nigronia	0.00	0.93
OLIGOCHAETA	9.17	0.00
ORTHOCLADIINAE	33.03	13.89
Prosimulium	0.00	0.93
Pseudolimnophila	0.00	0.93
SPHAERIIDAE	0.00	0.93
Sphaerium	1.83	0.00
Stegopterna	0.92	1.85
Synurella	26.61	36.11
TANYPODINAE	1.83	1.85
TANYTARSINI	1.83	0.00
Tipula	0.00	2.78
TUBIFICIDAE	0.00	0.93

PRET-111-C-2001

Taxon	Duplicate Data	Original Data
Acentrella	0.75	0.00
Amphinemura	3.01	5.31
Anchytarsus	0.00	0.88
BAETIDAE	0.75	2.65
Chelifera	0.00	2.65
CHIRONOMINI	3.01	0.88
DIAMESINAE	0.75	0.00
Diplectrona	0.00	0.88
Dixa	0.00	0.88
Ephemerella	50.38	56.64
Hydropsyche	3.01	0.88
HYDROPSYCHIDAE	0.75	0.00
LEPTOPHLEBIIDAE	0.75	0.00
Leuctra	6.77	0.00
LEUCTRIDAE	0.00	6.19
NAIDIDAE	0.75	0.00
Neophylax	4.51	4.42
Optioservus	2.26	2.65
Ormosia	0.00	0.88
ORTHOCLADIINAE	6.02	3.54
Paraleptophlebia	0.75	0.00
PERLIDAE	5.26	0.00
PERLODIDAE	0.00	5.31
Prosimulium	1.50	1.77
SIMULIIDAE	0.75	0.00
Simulium	1.50	0.88
Stagnicola	0.75	0.00
Stenonema	0.75	0.00
TANYPODINAE	1.50	0.00
TANYTARSINI	3.01	1.77
TURBELLARIA	0.75	0.00
TUBIFICIDAE	0.00	0.88

PRUN-103-R-2001

Taxon	Duplicate Data	Original Data
Amphinemura	8.26	11.21
Bezzia	0.00	0.93
Ceratopogon	0.00	1.87
Chelifera	0.83	0.00
CHIRONOMINI	5.79	4.67
CHLOROPERLIDAE	4.13	0.00
Dicranota	2.48	0.93
Diplectrona	5.79	0.00
Dolophilodes	1.65	0.93
ENCHYTRAEIDAE	0.00	0.93
Ephemerella	6.61	3.74
Hexatoma	3.31	0.93
Hydropsyche	1.65	1.87
Leuctra	2.48	26.17
LEUCTRIDAE	33.06	0.00
LUMBRICULIDAE	0.00	2.80
Molophilus	0.83	0.00
Nixe	0.83	0.00
ORTHOCLADIINAE	12.40	6.54
Oulimnius	0.00	0.93
Paraleptophlebia	0.83	0.00
Paraphaenocladius	0.00	11.21
PERLODIDAE	0.83	0.00
Peltoperla	0.00	0.93
Polycentropus	0.00	0.93
Potamyia	0.00	2.80
Prosimulium	0.00	0.93
Rhyacophila	1.65	1.87
SIMULIIDAE	0.83	0.00
Sweltsa	1.65	5.61
TANYTARSINI	4.13	10.28
Tipula	0.00	0.93

SAVA-101-C-2001

Taxon	Duplicate Data	Original Data
Acroneuria	0.00	0.87
Ameletus	0.93	0.00
Amphinemura	0.93	0.87
BAETIDAE	2.78	5.22
CAMBARIDAE	0.93	0.00
Chelifera	0.93	0.00
Cheumatopsyche	0.00	1.74
CHIRONOMINI	0.93	2.61
CHLOROPERLIDAE	0.93	0.00
Cinygmula	21.30	0.00
DIAMESINAE	0.00	0.87
Dicranota	0.93	0.00
Diplectrona	5.56	4.35
Dolophilodes	0.93	0.00
ELMIDAE	0.00	0.87
Epeorus	15.74	8.70
Ephemerella	4.63	4.35
HEPTAGENIIDAE	0.00	20.00
Hexatoma	0.00	1.74
Lepidostoma	0.93	3.48
LEPTOPHLEBIIDAE	0.00	7.83
LEUCTRIDAE	1.85	2.61
Neophylax	0.93	0.87
ORTHOCLADIINAE	2.78	0.87
Oulimnius	0.00	1.74
Paracapnia	0.93	0.87
Paraleptophlebia	8.33	0.00
PERLODIDAE	0.00	1.74
Prosimulium	2.78	3.48
Pteronarcys	0.00	1.74
Rhyacophila	1.85	0.87
Stenacron	0.00	1.74
Sweltsa	0.93	1.74
TANYPODINAE	0.00	0.87
Tallaperla	0.93	0.00
TANYTARSINI	20.37	17.39

SENE-205-R-2001

Taxon	Duplicate Data	Original Data
Antocha	1.75	0.90
Cheumatopsyche	9.65	9.01
CHIRONOMIDAE	0.00	4.50
CHIRONOMINI	3.51	2.70
Crangonyx	1.75	0.90
DIAMESINAE	0.88	0.90
Dugesia	2.63	0.90
GORDIIDAE	0.88	0.90
Hemerodromia	0.88	2.70
Hydropsyche	2.63	1.80
Hydroptila	0.88	0.00
Isonychia	0.88	0.00
NAIDIDAE	1.75	2.70
ORTHOCLADIINAE	54.39	48.65
Oulimnius	0.00	0.90
Simulium	1.75	2.70
SPHAERIIDAE	0.88	0.00
Stenelmis	5.26	0.90
Stenonema	2.63	1.80
TANYTARSINI	7.02	14.41
TUBIFICIDAE	0.00	0.90

UPPC-103-R-2001

Taxon	Duplicate Data	Original Data
Caecidotea	15.25	8.74
Caenis	3.39	11.65
Calopteryx	0.00	0.97
CERATOPOGONIDAE	0.00	0.97
CHIRONOMIDAE	0.00	6.80
CHIRONOMINI	9.32	12.62
COENAGRIONIDAE	0.00	1.94
Crangonyx	7.63	1.94
Dineutus	0.85	0.00
Hydroporus	0.00	2.91
Isotomurus	0.00	0.97
ORTHOCLADIINAE	33.90	33.01
Palaemonetes	0.00	0.97
Polycentropus	0.00	0.97
Procambarus	1.69	0.00
Somatochlora	0.85	0.00
TANYPODINAE	21.19	9.71
TANYTARSINI	5.93	5.83

WEBR-212-R-2001

Taxon	Duplicate Data	Original Data
Ablabesmyia	0.00	4.95
Ancyronyx	0.91	0.00
Argia	0.00	4.95
Caecidotea	0.91	0.00
Calopteryx	0.91	4.95
Chelifera	0.91	0.00
Cheumatopsyche	4.55	2.97
CHIRONOMIDAE	0.00	14.85
CHIRONOMINI	0.00	1.98
COENAGRIONIDAE	5.45	0.99
Gammarus	0.00	0.99
GORDIIDAE	3.64	0.00
Hemerodromia	2.73	0.00
Hyalella	0.91	0.00
Hydropsyche	0.91	0.99
HYDROPSYCHIDAE	0.91	0.99
Limnodrilus	0.00	3.96
LUMBRICULIDAE	0.00	0.99
OLIGOCHAETA	10.91	0.00
ORTHOCLADIINAE	36.36	39.60
Procambarus	0.91	0.00
Prosimulium	0.00	0.99
Ptilostomis	0.91	0.99
Sphaerium	0.00	0.99
TANYPODINAE	27.27	2.97
TANYTARSINI	0.91	0.00
TUBIFICIDAE	0.00	3.96

YOUG-110-R-2001

Taxon	Duplicate Data	Original Data
BAETIDAE	0.00	0.99
Caecidotea	0.85	0.00
Cheumatopsyche	0.85	0.99
CHIRONOMIDAE	0.00	7.92
CHIRONOMINI	5.13	4.95
DOLICHOPODIDAE	0.85	0.00
Dubiraphia	4.27	3.96
Ephemerella	0.00	0.99
Gammarus	16.24	17.82
Hemerodromia	0.00	0.99
Hexatoma	0.85	0.99
LUMBRICULIDAE	0.85	2.97
NAIDIDAE	1.71	0.00
OLIGOCHAETA	5.98	0.00
Optioservus	11.11	9.90
Ormosia	0.00	0.99
ORTHOCLADIINAE	20.51	21.78
Physella	1.71	1.98
Probezzia	0.85	0.00
Pseudolimnophila	0.00	0.99
Sphaerium	9.40	13.86
Tabanus	1.71	0.00
TANYPODINAE	7.69	0.00
TANYTARSINI	8.55	1.98
Tipula	0.85	0.00
TUBIFICIDAE	0.00	5.94

ZEKI-307-R-2001

Taxon	Duplicate Data	Original Data
Ablabesmyia	0.00	0.93
Acerpenna	0.00	0.93
Allocapnia	0.93	0.00
Ancyronyx	0.93	0.00
CHIRONOMINI	3.74	0.00
Calopteryx	0.00	0.93
Cheumatopsyche	0.00	3.74
CHIRONOMINI	0.00	3.74
Crangonyx	0.93	1.87
Eurylophella	0.93	1.87
GOMPHIDAE	0.00	1.87
Hemerodromia	0.00	1.87
Hexatoma	0.93	0.00
Hydropsyche	0.00	0.93
Isoperla	0.93	1.87
LEPTOPHLEBIIDAE	0.93	0.00
LEUCTRIDAE	0.93	0.00
LUMBRICULIDAE	0.00	0.93
Molannodes	0.00	0.93
OLIGOCHAETA	1.87	0.00
ORTHOCLADIINAE	7.48	1.87
Parametriocnemus	0.00	1.87
PERLODIDAE	0.93	0.00
Probezzia	0.93	0.00
Prosimulium	54.21	53.27
Pycnopsyche	0.93	0.00
Rhyacophila	0.93	0.00
Stegopterna	0.93	0.93
Stenelmis	0.93	0.00
Stenonema	0.93	1.87
Synurella	4.67	0.00
TANYPODINAE	0.00	0.93
TANYTARSINI	14.02	14.95
TUBIFICIDAE	0.00	1.87

APPENDIX E

Number of Individual Fish Species Sampled

Compared to Number Retained As Fish Voucher Specimens

Table E-1. Number of individual fish sampled compared to number retained as voucher specimens by 6-digit watershed in the 2000 and 2001 sampling seasons.

6-digit Watershed	**Species**	**# Sampled**	**# Vouchered**
Bush River	Cutlips Minnow	26	4
	RedBreast Sunfish	21	1
	Tessellated Darter	156	8
Chester River	Pumpkinseed	17	5
	Redbreast Sunfish	10	8
	White Sucker	36	3
Choptank River	Bluespotted Sunfish	7	0
	Brown Bullhead	20	2
	Chain Pickerel	10	5
	Fallfish	1	0
	Green Sunfish	1	0
	Largemouth Bass	24	5
	Least Brook Lamprey	139	6
	Mosquitofish	1	0
	Pumpkinseed	35	0
	Tessellated Darter	792	8
	Yellow Bullhead	8	4
Elk River	Banded Killifish	114	9
	Black Crappie	5	4
	Redfin Pickerel	12	9
	Satinfin Shiner	16	9
	Warmouth	1	0
	Yellow Bullhead	5	3
Gunpowder River	Bluegill	20	2
	Brook Trout	68	8
	Fantail Darter	116	9
	Green Sunfish	8	6
	Northern Hogsucker	94	16
	Redbreast	6	2
	Smallmouth Bass	14	2
	Swallowtail Shiner	10	9
	White Sucker	347	8
Lower Potomac River	Bluespotted Sunfish	145	8
	Brown Bullhead	33	9
	Central Stoneroller	25	0
	Chain Pickerel	75	5
	Eastern Silvery Minnow	1	0
	Flier	24	8
	Green Sunfish	7	2
	Ironcolor Shiner	20	0
	Largemouth Bass	87	5
	Longnose Dace	74	0
	Mummichog	1	0
	Pirate Perch	611	4
	Pumpkinseed	280	8
	Redfin Pickerel	637	6
	Satinfin Shiner	203	6
	Sea Lamprey	45	7
	White Sucker	39	0
	Yellow Bullhead	25	0

Table E-1. (Continued)

6-digit Watershed	Species	# Sampled	# Vouchered
Middle Potomac River	Brook Trout	19	0
	Brown Bullhead	2	1
	Brown Trout	49	9
	Common Shiner	3	1
	Creek Chub	263	0
	Creek Chubsucker	4	3
	Unknown Cyprinid	1	0
	Fallfish	10	7
	Green Sunfish	434	6
	Longear Sunfish	1	0
	Longnose Dace	379	0
	Margined Madtom	1	0
	Northern Hogsucker	23	0
	Redbreast Sunfish	70	9
	Rock Bass	12	5
	Smallmouth Bass	16	6
	Yellow Bullhead	15	6
Nanticoke River	American Eel	253	9
	Chain Pickerel	97	7
	Golden Shiner	1	0
	Largemouth Bass	13	3
	Margined Madtom	1	0
	Mosquitofish	11	8
	Pirate Perch	396	9
	Redfin Pickerel	7	5
	Swamp Darter	4	3
North Branch Potomac River	Blacknose Dace	597	0
	Brook Trout	416	0
	Creek Chub	313	0
	Fantail Darter	38	0
	Green Sunfish	1	0
	White Sucker	14	0
Ocean Coastal	Bluegill	357	9
	Creek Chubsucker	13	8
	Golden Shiner	89	7
	Largemouth Bass	23	9
	Mosquitofish	1	0
Patapsco River	American Eel	130	0
	Blacknose Dace	5722	2
	Bluegill	265	5
	Bluespotted Sunfish	30	0
	Bluntnose Minnow	2249	9
	Brook Trout	18	0
	Brown Trout	65	7
	Chain Pickerel	31	0
	Creek Chub	954	1
	Creek Chubsucker	26	7
	Fallfish	10	0
	Fathead Minnow	13	1
	Golden Shiner	38	3
	Green Sunfish	75	6
	Largemouth Bass	57	6
	Least Brook Lamprey	54	0
	Lepomis hybrid	6	5
	Margined Madtom	17	0

Table E-1. (Continued)

6-digit Watershed	Species	# Sampled	# Vouchered
	Mosquitofish	11	0
	Pumpkinseed	34	4
	Rainbow Trout	2	0
	Redfin Pickerel	24	0
	Rosyface Shiner	1	0
	Smallmouth Bass	10	6
	Spottail Shiner	14	0
	Swallowtail Shiner	188	0
	Yellow Bullhead	3	0
	Yellow Perch	1	0
Patuxent River	Fathead Minnow	20	9
	Largemouth Bass	114	9
	Lepomis hybrid	1	0
	Rainbow Trout	5	0
	Redfin Pickerel	71	8
	Spottail Shiner	25	0
	Yellow Bullhead	76	2
Pocomoke River	Americal Eel	184	5
	Black Crappie	1	0
	Bluegill	9	0
	Bluespotted Sunfish	935	2
	Chain Pickerel	6	0
	Largemouth Bass	6	4
	Mosquitofish	414	6
	Mud Sunfish	26	0
	Pumpkinseed	58	5
	Redbreast Sunfish	43	5
	Redfin Pickerel	336	1
	Swamp Darter	14	0
	Tessellated Darter	24	3
	Yellow Bullhead	60	7
	Yellow Perch	3	0
Susquehanna River	Blue Ridge Sculpin	683	9
	Bluegill	5	3
	Brook Trout	38	0
	Common Carp	2	0
	Cyprinid Hybrid	1	0
	Green Sunfish	1	0
	Largemouth Bass	8	1
	Logperch	9	7
	Rainbow Trout	2	0
	Sea Lamprey	187	6
	Smallmouth Bass	85	3
	Spottail Shiner	156	9
	White Perch	2	1
	Yellow Bullhead	1	0

Table E-1. (Continued)

6-digit Watershed	Species	# Sampled	# Vouchered
Upper Potomac River	Americal Eel	10	0
	Blacknose Dace	2075	5
	Bluegill	8	0
	Brown Trout	1	0
	Chain Pickerel	5	2
	Creek Chub	572	0
	Cutlips Minnow	44	3
	Golden Redhorse	3	2
	Goldfish	4	0
	Largemouth Bass	6	1
	Northern Hogsucker	40	9
	Potomac Sculpin	458	0
	Pumpkinseed	10	0
	Rainbow Darter	1018	1
	Rock Bass	345	7
	Smallmouth Bass	291	9
	Tessellated Darter	10	9
	White Sucker	75	6
Washington Metro	American Eel	53	1
	Black Crappie	3	0
	Bluegill	132	2
	Bluntnose Minnow	149	0
	Common Shiner	22	9
	Cyprinid Hybrid	1	0
	Fallfish	12	9
	Golden Shiner	9	2
	Green Sunfish	507	3
	Greenside Darter	74	0
	Least Brook Lamprey	6	1
	Mosquitofish	3	0
	Mottled Sculpin	294	0
	Northern Hogsucker	3	0
	Pumpkinseed	39	0
	Redbreast Sunfish	68	0
	River Chub	1	0
	Rock Bass	6	0
	Satinfin Shiner	12	0
	Sea Lamprey	3	0
	Smallmouth Bass	3	0
	Swallowtail Shiner	42	0
	Tadpole Madtom	1	0
	Tessellated Darter	105	0
	White Sucker	316	0
	Yellow Bullhead	17	0

Table E-1. (Continued)

6-digit Watershed	Species	# Sampled	# Vouchered
Youghiogheny River	Blacknose Dace	971	0
	Bluegill	15	0
	Brook Trout	275	0
	Brown Bullhead	30	3
	Brown Trout	1	0
	Central Stoneroller	1	0
	Common Shiner	3	0
	Chain Pickerel	2	0
	Golden Shiner	104	0
	Northern Hogsucker	37	5
	Pumpkinseed	49	0
	Rainbow Trout	5	0
	Redfin Pickerel	1	0
	River Chub	18	8
	Rock Bass	78	5
	Striped Shiner	1	0

Bush River Basin Voucher			Current as of: 04/30/02			
	# preserved specimens by sample year					**Total**
	2000	**2001**	**2002**	**2003**	**2004**	**(Need 10)**
Field Crew:		NS				
Species						0
American eel	18	0				18
Banded sunfish	3	0				3
Blacknose dace	10	0				10
Bluegill	10	0				10
Brown bullhead	2	0				2
Common shiner	10	0				10
Creek chub	10	0				10
Creek chubsucker	11	0				11
Cutlips minnow	4	0				4
Eastern mudminnow	13	0				13
Golden shiner	5	0				5
Goldfish	1	0				1
Green sunfish	1	0				1
Largemouth bass	2	0				2
Mummichog	10	0				10
Pumpkinseed	12	0				12
Redbreast sunfish	1	0				1
Redfin pickerel	12	0				12
Rosyside dace	10	0				10
Swallowtail shiner	10	0				10
Tadpole madtom	1	0				1
Tessellated darter	8	0				8
White sucker	10	0				10
Yellow bullhead	3	0				3

Chester River Basin Voucher			Current as of: 04/30/02			
	# preserved specimens by sample year					**Total**
	2000	**2001**	**2002**	**2003**	**2004**	**(Need 10)**
Field Crew:		Prochaska/Millard				
Species						
American eel	10	0				10
Bluegill	14	0				14
Brown bullhead	2	0				2
Creek chubsucker	10	0				10
Eastern mudminnow	10	0				10
Fallfish	10	0				10
Golden shiner	10	0				10
Largemouth bass	12	0				12
Least brook lamprey	10	0				10
Pumpkinseed	5	0				5
Redbreast sunfish	8	0				8
Redfin pickerel	10	0				10
Rosyside dace	10	0				10
Swallowtail shiner	13	0				13
Tadpole madtom	10	0				10
Tessellated darter	10	0				10
Warmouth	14	2				16
White sucker	3	0				3

Choptank River Basin Voucher			Current as of: 04/30/02			
	# preserved specimens by sample year					**Total**
	2000	**2001**	**2002**	**2003**	**2004**	**(Need 10)**
Field Crew:		NS				
Species						
American eel	10	0				10
Banded killifish	10	0				10
Black crappie	11	0				11
Bluegill	10	0				10
Brown bullhead	2	0				2
Chain pickerel	5	0				5
Creek chubsucker	10	0				10
Eastern mudminnow	10	0				10
Golden shiner	10	0				10
Largemouth bass	5	0				5
Least brook lamprey	6	0				6
Pirate perch	10	0				10
Redbreast sunfish	10	0				10
Redfin pickerel	10	0				10
Satinfin shiner	10	0				10
Swallowtail shiner	15	0				15
Swamp darter	1	0				1
Tadpole madtom	10	0				10
Tessellated darter	8	0				8
White sucker	1	0				1
Yellow bullhead	5	0				5
Yellow perch	1	0				1

Elk River Basin Voucher			Current as of: 04/30/02			
			# preserved specimens by sample year			**Total**
	2000	**2001**	**2002**	**2003**	**2004**	**(Need 10)**
Field Crew:	NS	Prochaska/Millard				
Species						
American eel	0	10				10
Banded killifish	0	9				9
Black crappie	0	4				4
Blacknose dace	0	10				10
Blue ridge sculpin	0	10				10
Bluegill	0	10				10
Brown bullhead	0	15				15
Common shiner	0	10				10
Creek chub	0	10				10
Creek chubsucker	0	10				10
Cutlips minnow	0	10				10
Eastern mudminnow	0	10				10
Fathead minnow	0	1				1
Golden shiner	0	10				10
Green sunfish	0	10				10
Largemouth bass	0	10				10
Least brook lamprey	0	10				10
Longnose dace	0	10				10
Margined madtom	0	10				10
Mosquitofish	0	10				10
Northern hogsucker	0	10				10
Pumpkinseed	0	10				10
Redbreast sunfish	0	10				10
Redfin pickerel	0	9				9
River chub	0	10				10
Rosyside dace	0	10				10
Satinfin shiner	0	9				9
Smallmouth bass	0	8				8
Spottail shiner	0	10				10
Swallowtail shiner	0	10				10
Tessellated darter	0	10				10
White sucker	0	10				10
Yellow bullhead	0	3				3

Gunpowder River Basin Voucher			Current as of: 04/30/02			
			# preserved specimens by sample year			**Total**
	2000	**2001**	**2002**	**2003**	**2004**	**(Need 10)**
Field Crew:						
Species						
American eel	0	10				10
Blacknose dace	10	10				20
Bluegill	2	0				2
Blue ridge sculpin	10	0				10
Bluntnose minnow	10	0				10
Brook trout	4	4				8
Central stoneroller	11	0				11
Common shiner	10	10				20
Creek chub	11	10				21
Cutlips minnow	0	10				10
Cyprinid hybrid	0	3				3
Fantail darter	9	0				9
Green sunfish	6	0				6
Largemouth bass	1	0				1
Longnose dace	10	10				20
Margined madtom	0	10				10
Northern hogsucker	6	10				16
Potomac sculpin	30	0				30
Redbreast sunfish	0	2				2
River chub	0	10				10
Rosyface shiner	0	11				11
Rosyside dace	10	10				20
Satinfin shiner	0	10				10
Shield darter	0	10				10
Swallowtail shiner	0	9				9
Sea lamprey	0	10				10
Smallmouth bass	0	2				2
Tessellated darter	0	10				10
White sucker	9	1				10
Yellow bullhead	2	0				2

Lower Potomac River Basin Voucher			Current as of: 04/30/02			
		# preserved specimens by sample year				**Total**
	2000	**2001**	**2002**	**2003**	**2004**	**(Need 10)**
Field Crew:		Stranko/Kilian/Hurd				
Species						
American eel	14	0				14
Black crappie	2	0				2
Blacknose dace	21	0				21
Bluegill	2	8				10
Bluespotted sunfish	8	2				10
Brown bullhead	9	1				10
Chain pickerel	2	14				16
Creek chub	20	0				20
Creek chubsucker	17	0				17
Eastern mudminnow	20	1				21
Fallfish	21	0				21
Flier	1	7				8
Golden shiner	1	9				10
Green sunfish	2	0				2
Ironcolor shiner	23	0				23
Largemouth bass	5	5				10
Least brook lamprey	7	3				10
Lepomis Hybrid	0	1				1
Margined madtom	4	6				10
Mosquitofish	0	2				2
Pirate perch	1	9				10
Pumpkinseed	4	12				16
Redbreast sunfish	2	9				11
Redfin pickerel	9	1				10
Rosyside dace	14	1				15
Satinfin shiner	0	6				6
Sea lamprey	5	6				11
Spottail shiner	0	1				1
Swallowtail shiner	0	10				10
Swamp Darter	0	6				6
Tadpole madtom	15	0				15
Tessellated darter	24	0				24
Warmouth	18	0				18
White sucker	14	0				14
Yellow bullhead	0	1				1
Yellow perch	0	1				1

Middle Potomac River Basin Voucher		Current as of: 04/30/02				
		# preserved specimens by sample year				**Total**
	2000	**2001**	**2002**	**2003**	**2004**	**(Need 10)**
Field Crew:		NS				
Species						
Banded killifish	28	0				28
Blacknose dace	19	0				19
Bluegill	11	0				11
Bluntnose minnow	10	0				10
Brook trout	20	0				20
Brown bullhead	1	0				1
Brown trout	9	0				9
Central stoneroller	20	0				20
Checkered sculpin	8	0				8
Comely shiner	2	0				2
Common shiner	1	0				1
Creek chubsucker	10	0				10
Cutlips minnow	20	0				20
Eastern silvery minnow	4	0				4
Fallfish	7	0				7
Fantail darter	23	0				23
Fathead minnow	6	0				6
Golden redhorse	17	0				17
Golden shiner	27	0				27
Goldfish	1	0				1
Green sunfish	9	0				9
Greenside darter	19	0				19
Largemouth bass	17	0				17
Lepomis hybrid	4	0				4
Longear sunfish	40	0				40
Mosquitofish	29	0				29
Mottled sculpin	32	0				32
Northern hogsucker	1	0				1
Pearl dace	12	0				12
Potomac sculpin	12	0				12
Pumpkinseed	10	0				10
Rainbow darter	2	0				2
Redbreast sunfish	9	0				9
Rock bass	5	0				5
Rosyface shiner	12	0				12
Rosyside dace	15	0				15
Silverjaw minnow	45	0				45
Smallmouth bass	6	0				6
Spotfin shiner	154	0				154
Spottail shiner	30	0				30
Tessellated darter	21	0				21
White sucker	21	0				21
Yellow bullhead	6	0				6

Nanticoke/Wicomico River Basin Voucher	Current as of: 04/30/02					
	# preserved specimens by sample year					**Total**
	2000	**2001**	**2002**	**2003**	**2004**	**(Need 10)**
Field Crew:		**Kline**				
Species						
American eel	14	0				14
Banded sunfish	64	0				64
Black crappie	1	0				1
Bluegill	10	0				10
Bluespotted sunfish	13	0				13
Brown bullhead	11	0				11
Chain pickerel	10	0				10
Creek chubsucker	0	1				1
Eastern mudminnow	11	3				14
Largemouth bass	3	0				3
Least brook lamprey	0	7				7
Margined madtom	1	0				1
Mosquitofish	8	0				8
Pirate perch	11	0				11
Pumpkinseed	9	0				9
Redfin pickerel	5	0				5
Swamp darter	3	0				3
Tessellated darter	0	5				5
White perch	2	0				2
Yellow bullhead	11	0				11
Yellow perch	1	0				1

Patapsco River Basin Voucher			Current as of: 04/30/02			
		# preserved specimens by sample year				**Total**
	2000	**2001**	**2002**	**2003**	**2004**	**(Need 10)**
Field Crew:		Prochaska/Millard				
Species						
Blacknose dace	2	10				12
Bluegill	5	0				5
Blue Ridge Sculpin	0	10				10
Bluntnose minnow	9	0				9
Brown bullhead	0	10				10
Brown trout	7	0				7
Central stoneroller	10	0				10
Channel catfish	1	0				1
Common shiner	10	0				10
Creek chub	1	9				10
Creek chubsucker	0	7				7
Cutlips minnow	10	0				10
Eastern mudminnow	8	11				19
Fathead minnow	1	1				2
Glassy darter	1	0				1
Golden shiner	1	2				3
Goldfish	0	4				4
Green sunfish	6	0				6
Largemouth bass	6	0				6
Lepomis hybrid	5	0				5
Longnose dace	10	0				10
Mummichog	0	1				1
Northern hogsucker	10	0				10
Pumpkinseed	0	4				4
Redbreast sunfish	11	0				11
River chub	10	0				10
Rock bass	10	0				10
Rosyside dace	10	0				10
Smallmouth bass	6	0				6
Spottail Shiner	0	10				10
Tessellated darter	10	0				10
White sucker	10	0				10
Yellow Bullhead	0	4				4

Patuxent River Basin Voucher			Current as of: 04/30/02			
			# preserved specimens by sample year			**Total**
	2000	**2001**	**2002**	**2003**	**2004**	**(Need 10)**
Field Crew:						
Species						
American brook lamprey	15	0				15
American eel	13	0				13
Blacknose dace	10	0				10
Bluegill	10	0				10
Bluespotted sunfish	0	2				2
Brown bullhead	2	9				11
Brown trout	10	0				10
Central stoneroller	10	0				10
Chain pickerel	0	1				1
Common shiner	10	0				10
Creek chub	11	0				11
Creek chubsucker	0	6				6
Cutlips minnow	10	0				10
Eastern mudminnow	2	10				12
Fallfish	10	0				10
Fathead minnow	9	0				9
Gizzard shad	7	0				7
Glassy darter	10	0				10
Golden Shiner	0	10				10
Green sunfish	11	0				11
Largemouth bass	9	0				9
Least brook lamprey	4	8				12
Spotfin shiner	12	0				12
Longnose dace	10	0				10
Margined madtom	20	0				20
Mosquitofish	2	0				2
Mottled sculpin	10	0				10
Northern hogsucker	11	0				11
Pirate perch	0	10				10
Pumpkinseed	2	11				13
Redbreast sunfish	10	0				10
Redfin pickerel	0	8				8
River chub	10	0				10
Rosyface shiner	7	0				7
Rosyside dace	10	0				10
Satinfin shiner	10	0				10
Sea lamprey	15	2				17
Shield darter	14	0				14
Smallmouth bass	10	0				10
Swallowtail shiner	11	0				11
Tadpole madtom	0	3				3
Tessellated darter	11	0				11
White sucker	11	0				11
Yellow bullhead	1	1				2

Pocomoke River Basin Voucher			Current as of: 04/30/02			
		# preserved specimens by sample year				**Total**
	2000	**2001**	**2002**	**2003**	**2004**	**(Need 10)**
Field Crew:		**Kline**				
Species						
American eel	0	5				5
Banded sunfish	5	47				52
Bluegill	0	1				1
Bluespotted sunfish	0	36				36
Brown bullhead	0	6				6
Chain pickerel	0	5				5
Creek chubsucker	0	5				5
Eastern mudminnow	0	2				2
Golden shiner	0	23				23
Largemouth bass	0	2				2
Least brook lamprey	0	1				1
Mosquitofish	0	6				6
Pirate perch	0	30				30
Pumpkinseed	0	5				5
Redbreast sunfish	0	5				5
Redfin pickerel	7	1				8
Satinfin Shiner	0	4				4
Swamp darter	8	0				8
Tadpole madtom	0	13				13
Tessellated darter	0	3				3
Yellow bullhead	0	8				8
Yellow perch	0	5				5

Potomac Washington-Metro River Basin Voucher					Current as of: 04/30/02	
	# preserved specimens by sample year					**Total**
	2000	**2001**	**2002**	**2003**	**2004**	**(Need 10)**
Field Crew:		Kline; Stranko/Kilian/Hurd				
Species						
American eel	9	1				10
Banded killifish	10	0				10
Blacknose dace	3	29				32
Bluegill	7	3				10
Blueridge sculpin	0	10				10
Bluntnose minnow	10	0				10
Brown bullhead	9	1				10
Central stoneroller	0	21				21
Chain pickerel	0	3				3
Comely shiner	0	29				29
Common carp	2	0				2
Common shiner	0	9				9
Creek chub	0	10				10
Creek chubsucker	2	10				12
Cutlips minnow	3	1				4
Eastern mudminnow	0	10				10
Eastern silvery minnow	0	1				1
Fallfish	0	9				9
Fantail darter	0	20				20
Golden shiner	8	2				10
Green sunfish	9	3				12
Goldfish	3	1				4
Least brook lamprey	0	1				1
Longnose dace	0	29				29
Margined madtom	0	10				10
Mosquitofish	1	0				1
Mummichog	10	0				10
Northern hogsucker	1	0				1
Pirate perch	0	1				1
Potomac sculpin	0	10				10
Pumpkinseed	13	0				13
Redbreast sunfish	13	0				13
Rosyside dace	0	29				29
Satinfin shiner	11	0				11
Sea lamprey	16	0				16
Silverjaw minnow	0	15				15
Smallmouth bass	0	10				10
Spottail shiner	11	0				11
Swallowtail shiner	10	0				10
Tadpole madtom	0	1				1
Tessellated darter	12	0				12
White sucker	10	0				10
Yellow bullhead	11	0				11
Yellow perch	1	0				1

Susquehanna River Basin Voucher			Current as of: 04/30/02			
		# preserved specimens by sample year				**Total**
	2000	**2001**	**2002**	**2003**	**2004**	**(Need 10)**
Field Crew:	NS	Prochaska/Millard				
Species						
American eel	0	10				10
Blacknose dace	0	10				10
Bluegill	0	3				3
Blue ridge sculpin	0	9				9
Brown trout	0	24				24
Common shiner	0	10				10
Creek chub	0	11				11
Cutlips minnow	0	10				10
Eastern silvery minnow	0	4				4
Fallfish	0	10				10
Largemouth bass	0	1				1
Logperch	0	7				7
Longnose dace	0	10				10
Margined madtom	0	12				12
Northern Hogsucker	0	10				10
Pumpkinseed	0	1				1
Redbreast Sunfish	0	10				10
River Chub	0	10				10
Rock Bass	0	11				11
Rosyface Shiner	0	10				10
Rosyside Dace	0	10				10
Satinfin Shiner	0	10				10
Sea Lamprey	0	6				6
Shield Darter	0	10				10
Smallmouth Bass	0	3				3
Spottail Shiner	0	9				9
Swallowtail Shiner	0	10				10
Tessellated Darter	0	10				10
White Perch	0	1				1
White sucker	0	14				14
Yellow Perch	0	2				2

Upper Potomac River Basin Voucher			Current as of: 04/30/02			
			# preserved specimens by sample year			**Total**
	2000	**2001**	**2002**	**2003**	**2004**	**(Need 10)**
Field Crew:		**Kline**				
Species						
Blacknose dace	5	10				15
Bluntnose minnow	10	0				10
Central stoneroller	10	0				10
Chain pickerel	2	2				4
Comely shiner	42	2				44
Common shiner	22	0				22
Creek chub	0	9				9
Cutlips minnow	3	0				3
Fallfish	10	0				10
Fantail darter	11	0				11
Golden redhorse	2	0				2
Green sunfish	10	0				10
Greenside darter	11	0				11
Largemouth bass	1	0				1
Longear sunfish	11	3				14
Longnose dace	15	10				25
Margined madtom	15	0				15
Mottled sculpin	11	0				11
Northern hogsucker	9	0				9
Pearl dace	11	0				11
Potomac sculpin	0	10				10
Rainbow darter	1	0				1
Redbreast sunfish	11	0				11
River chub	17	0				17
Rock bass	7	0				7
Rosyface shiner	190	7				197
Silverjaw minnow	11	0				11
Smallmouth bass	9	0				9
Spotfin shiner	144	0				144
Spottail shiner	10	0				10
Tessellated darter	9	0				9
White sucker	6	0				6
Yellow bullhead	13	0				13

Youghiogheny River Basin Voucher	Current as of: 04/30/02					
	# preserved specimens by sample year					**Total**
	2000	**2001**	**2002**	**2003**	**2004**	**(Need 10)**
Field Crew:	NS	**Kline**				
Species						
Black crappie	0	3				3
Blacknose dace	0	10				10
Bluntnose minnow	0	11				11
Brown bullhead	0	3				3
Central stoneroller	0	0				0
Chain pickerel	0	0				0
Comely shiner	0	0				0
Common shiner	0	0				0
Creek chub	0	20				20
Cutlips minnow	0	0				0
Fallfish	0	0				0
Fantail darter	0	0				0
Golden redhorse	0	0				0
Green sunfish	0	10				10
Greenside darter	0	3				3
Johnny darter	0	11				11
Largemouth bass	0	1				1
Longear sunfish	0	0				0
Longnose dace	0	10				10
Margined madtom	0	10				10
Mottled sculpin	0	30				30
Northern hogsucker	0	5				5
Pearl dace	0	0				0
Potomac sculpin	0	0				0
Rainbow darter	0	0				0
Redbreast sunfish	0	0				0
River chub	0	8				8
Rock bass	0	5				5
Rosyface shiner	0	0				0
Rosyside dace	0	1				1
Silverjaw minnow	0	0				0
Smallmouth bass	0	11				11
Spotfin shiner	0	0				0
Spottail shiner	0	0				0
Tessellated darter	0	0				0
White sucker	0	11				11
Yellow bullhead	0	8				8